

Figure 3-14. Groundwater Density

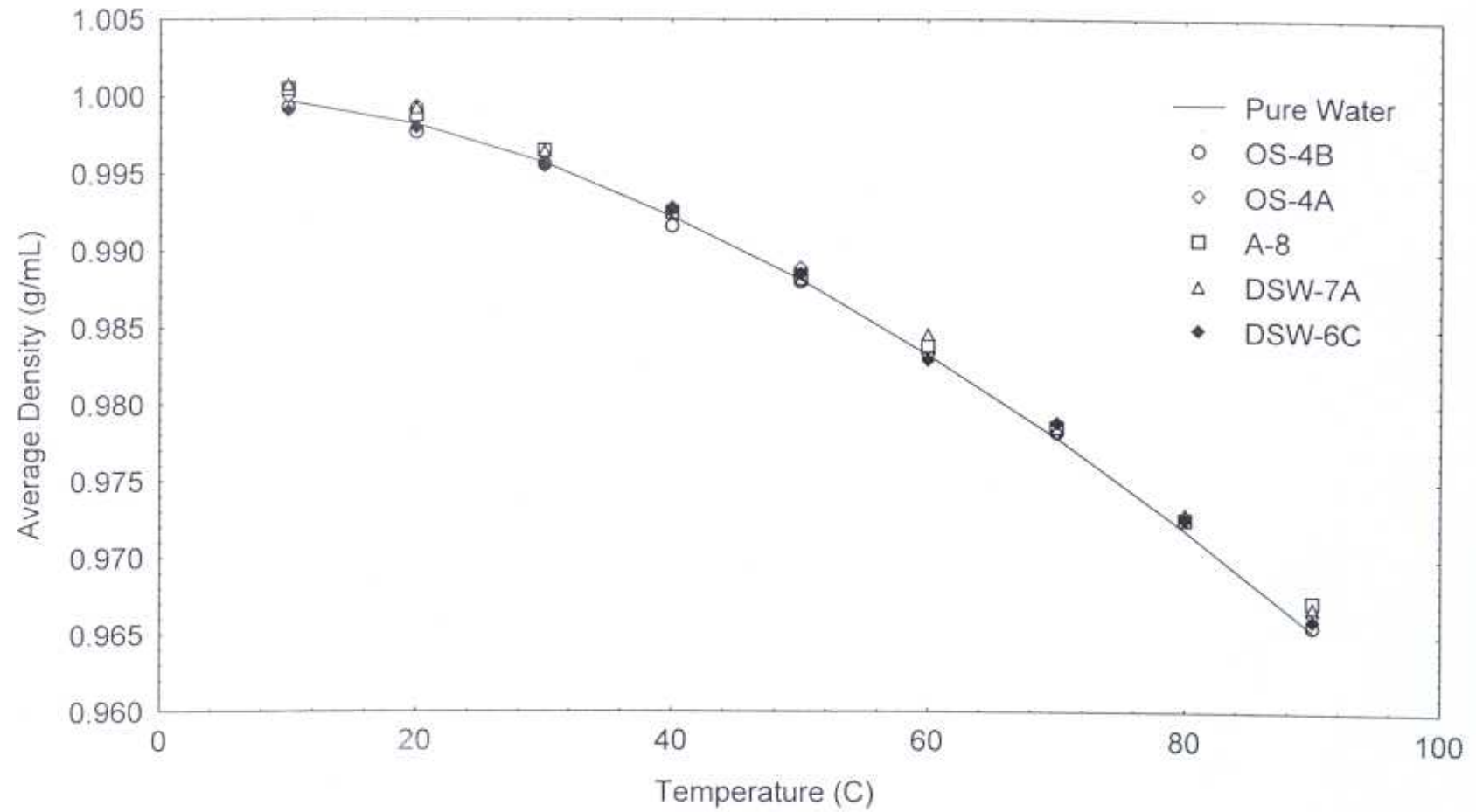


Figure 3-15
Well A-8 Naphthalene Trends

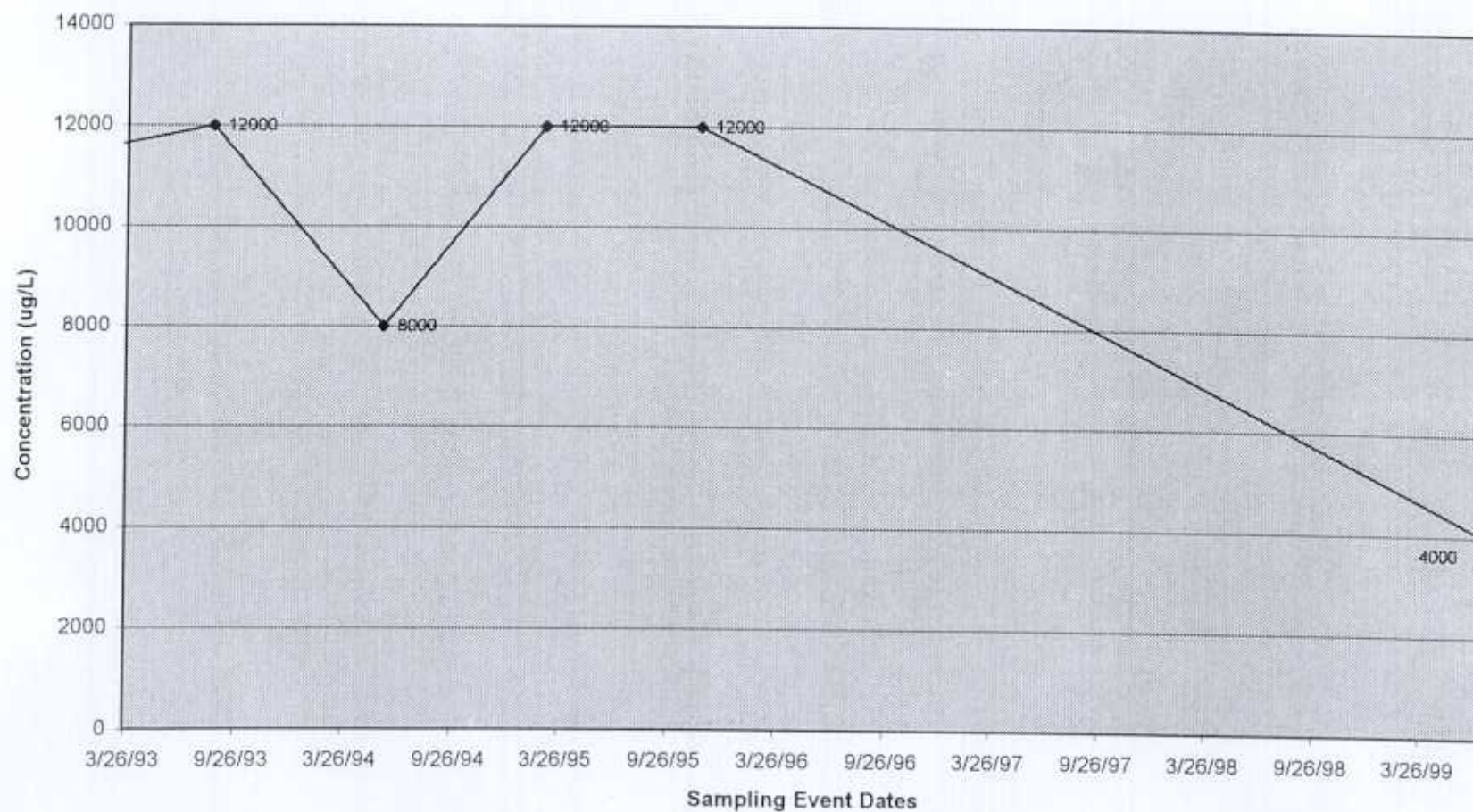


Figure 3-16
Well DSW-4B Naphthalene Trends

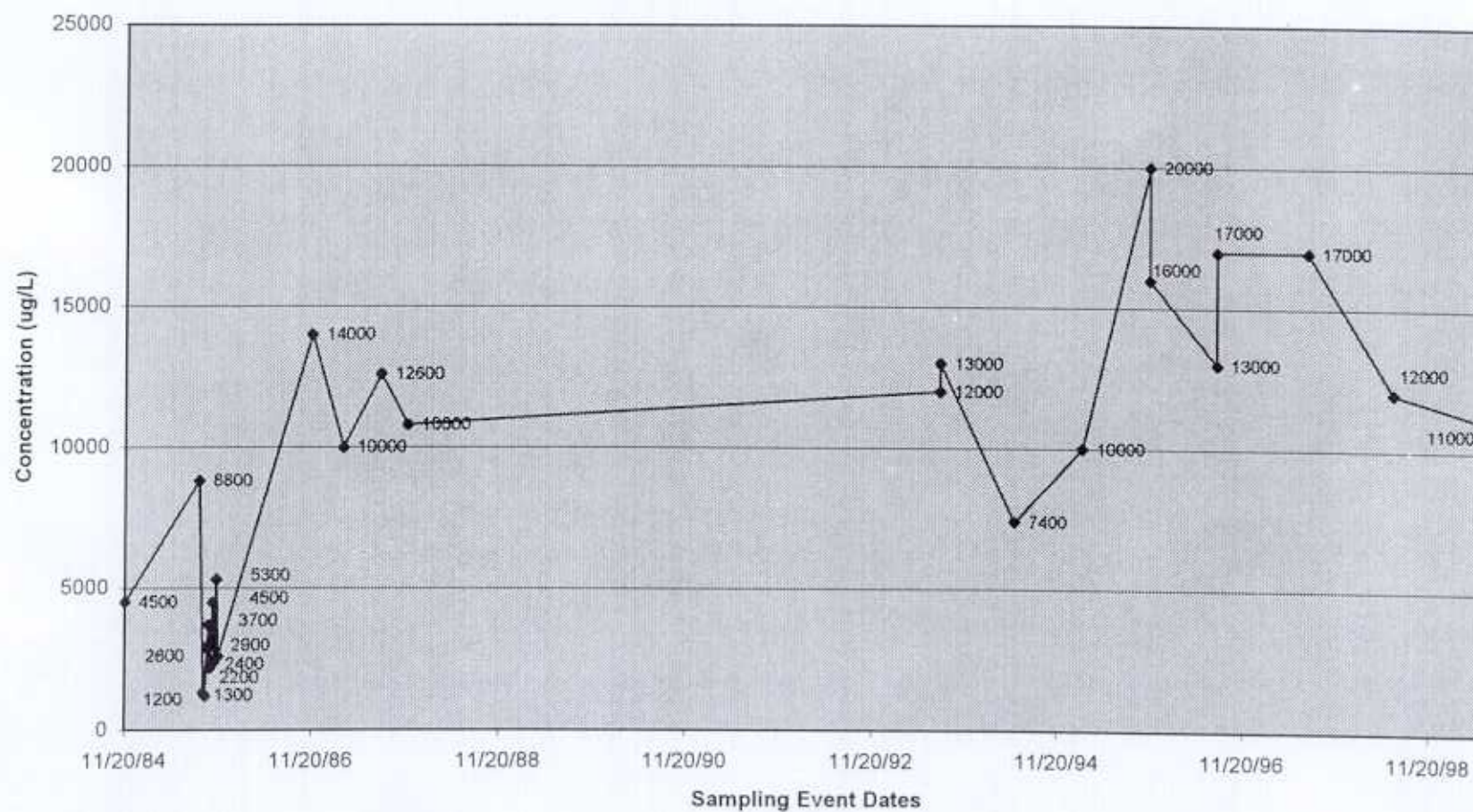


Figure 3-17
Well DSW-4C Naphthalene Trends

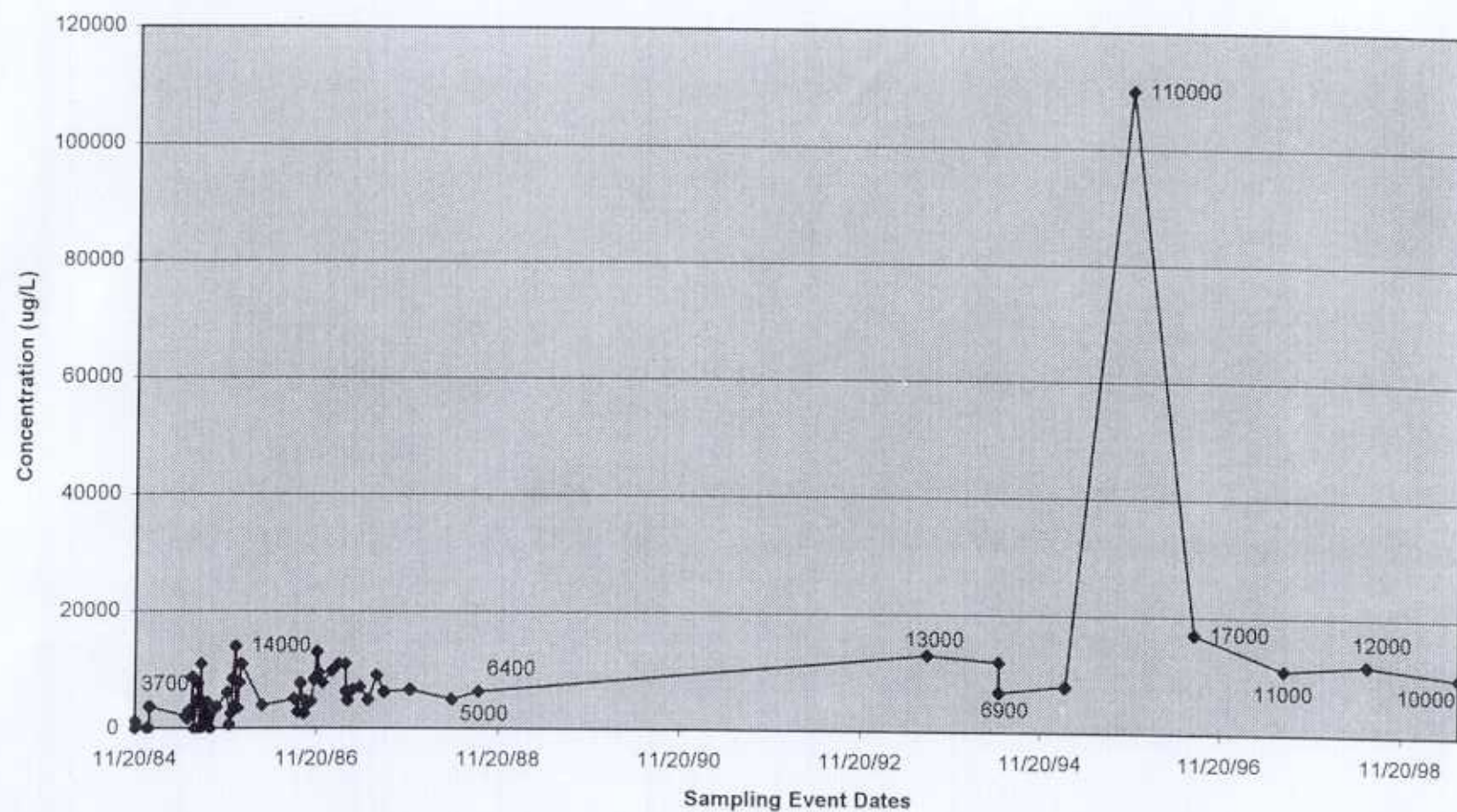


Figure 3-18
Well DSW-6B Naphthalene Trends

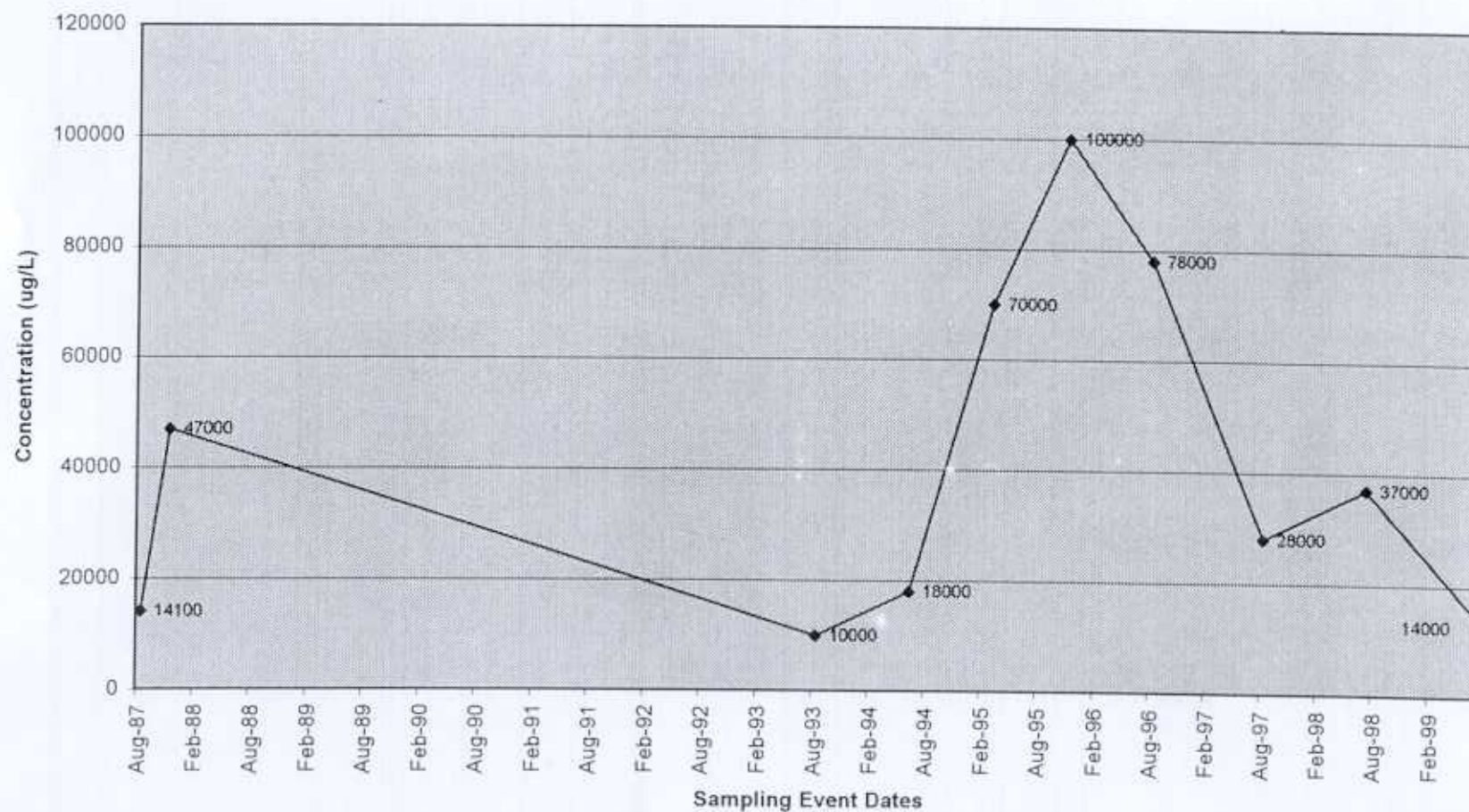


Figure 3-19
Well DSW-6C Naphthalene Trends

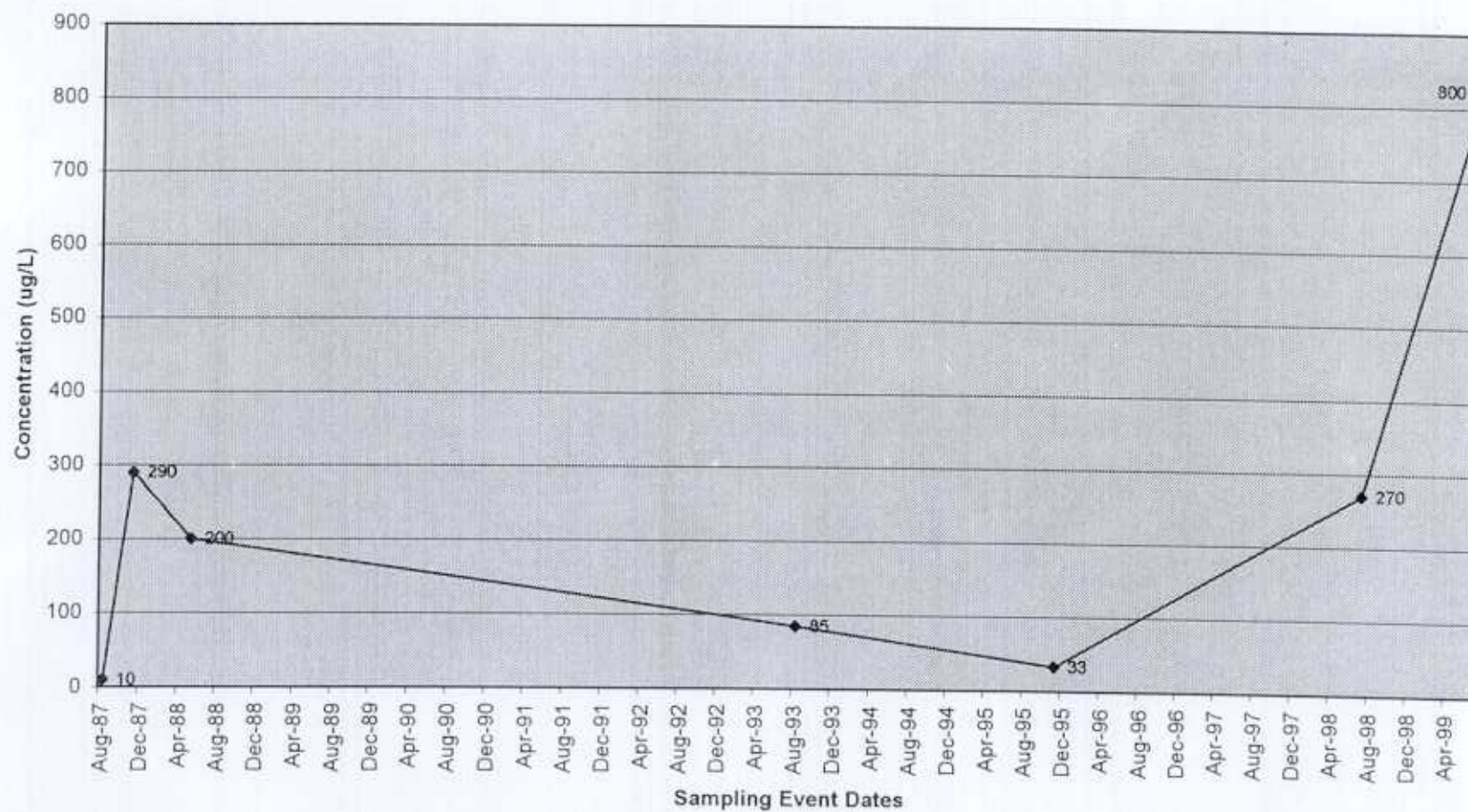


Figure 3-20
Well A-8 PCP Trends

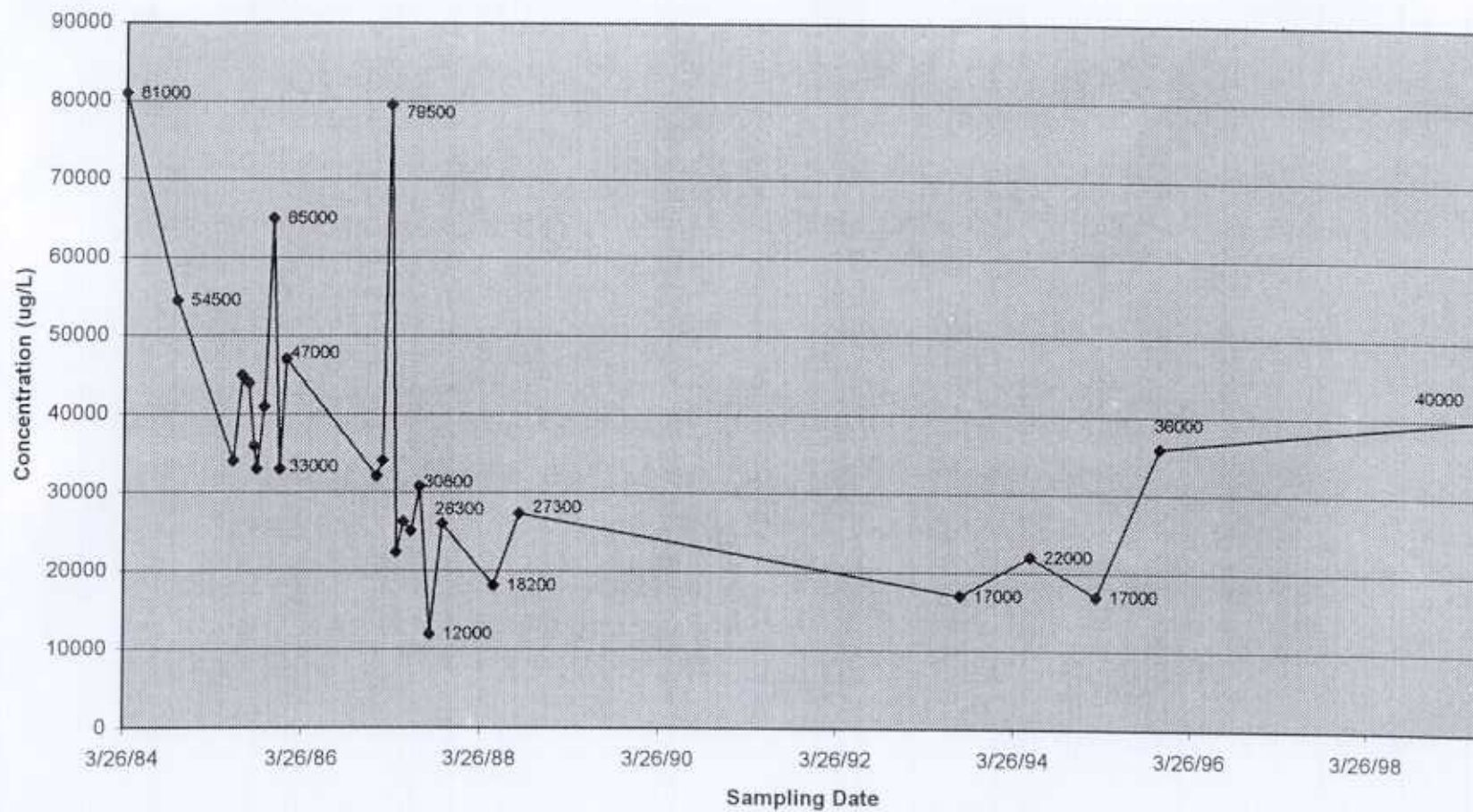


Figure 3-21
Well DSW-4B PCP Trends

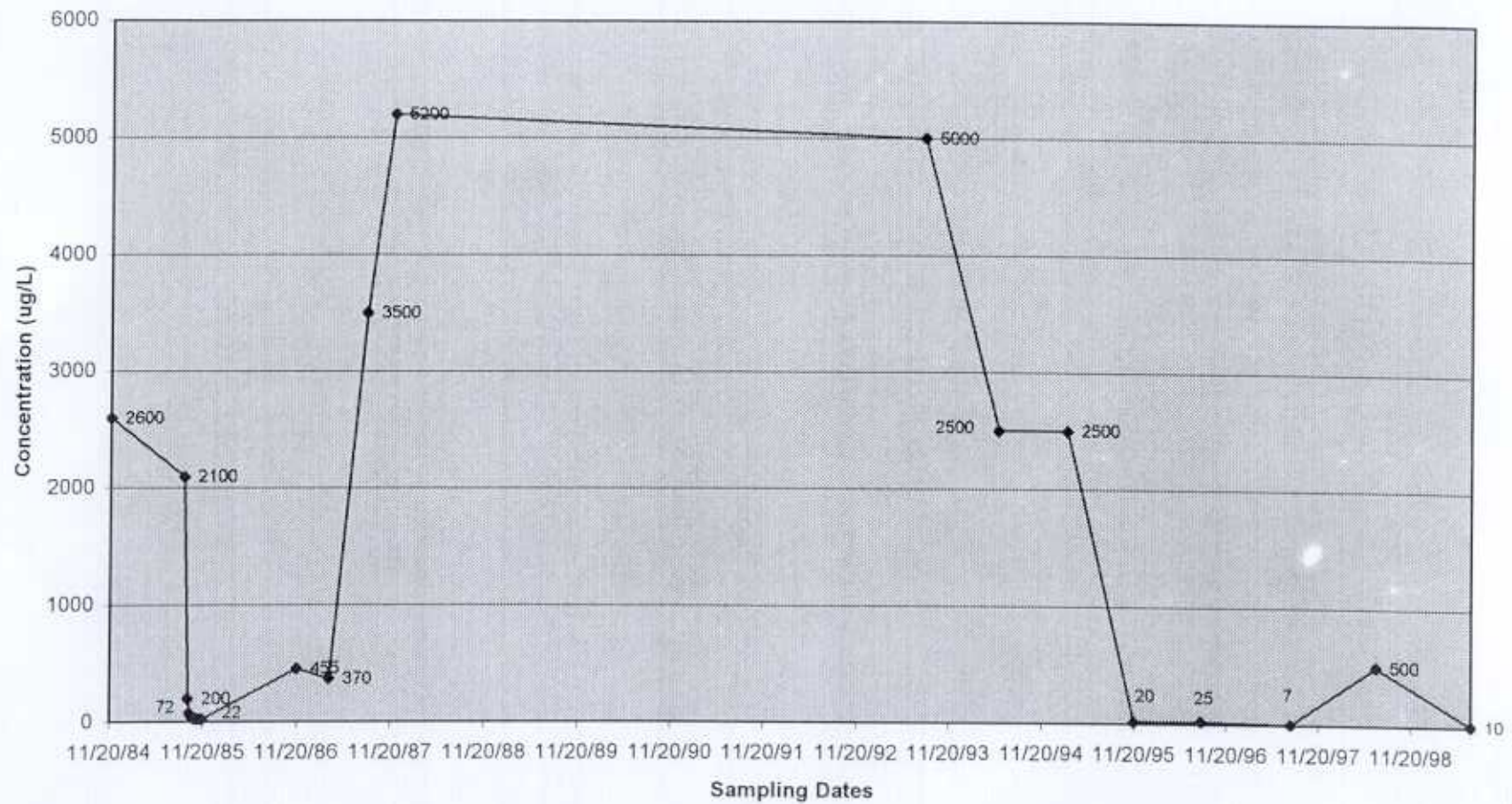


Figure 3-22
Well DSW-4C PCP Trends

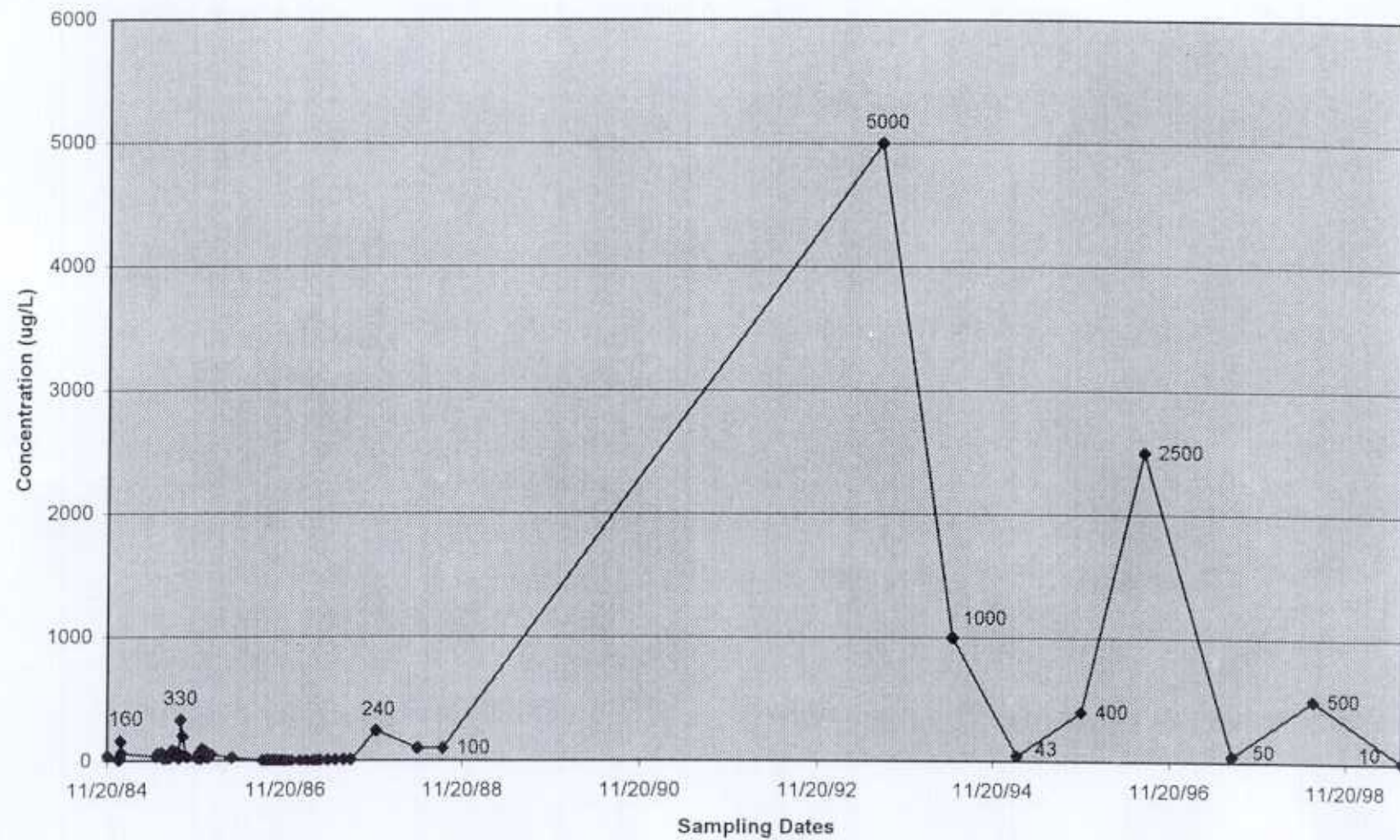


Figure 3-23
Well DSW-6B PCP Trends

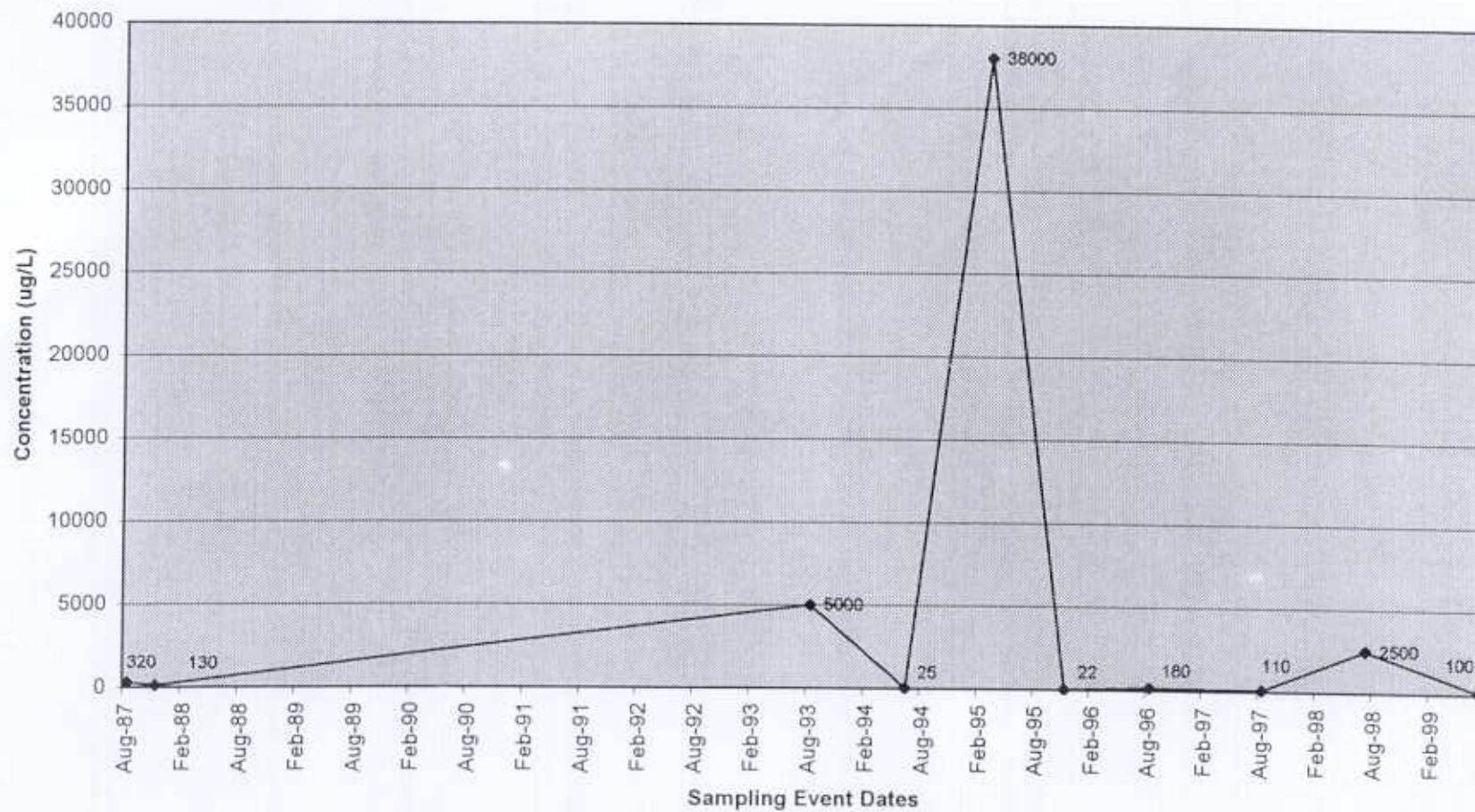


Figure 3-24
Well DSW-4B TCDD TEC Trends

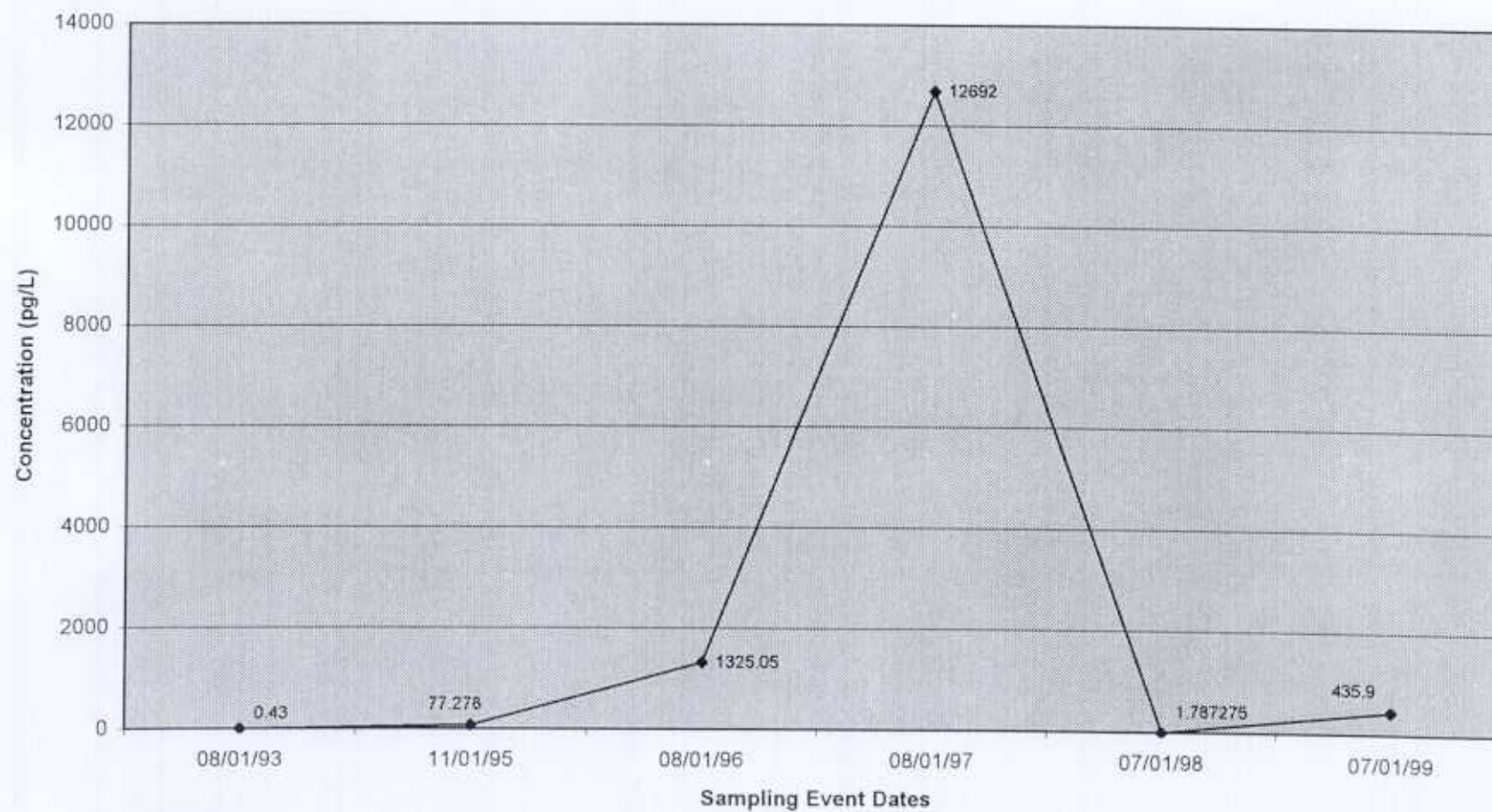


Figure 3-25
Well DSW-4C TCDD TEC Trends

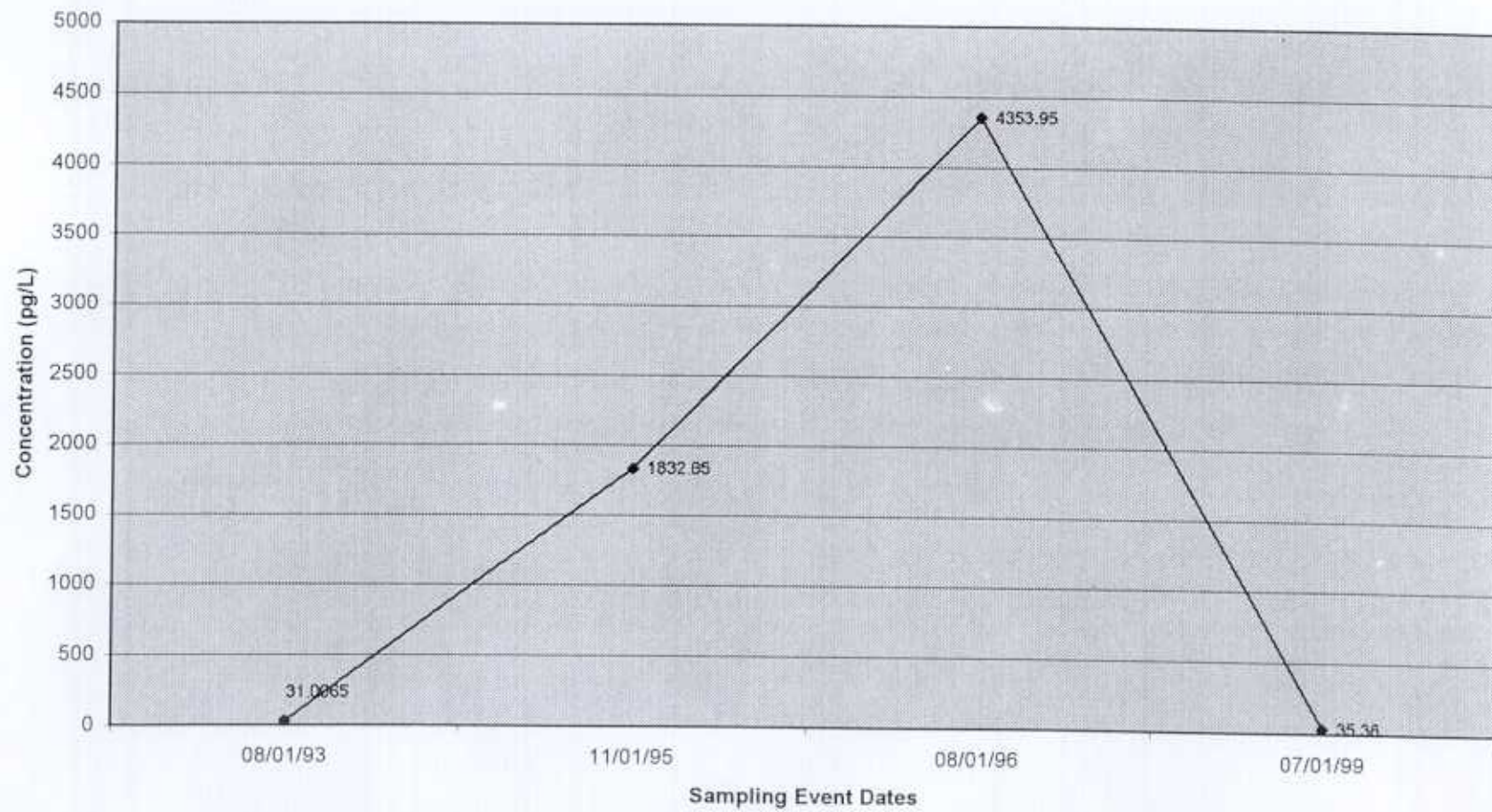


Figure 3-26
Well DSW-6B TCDD TEC

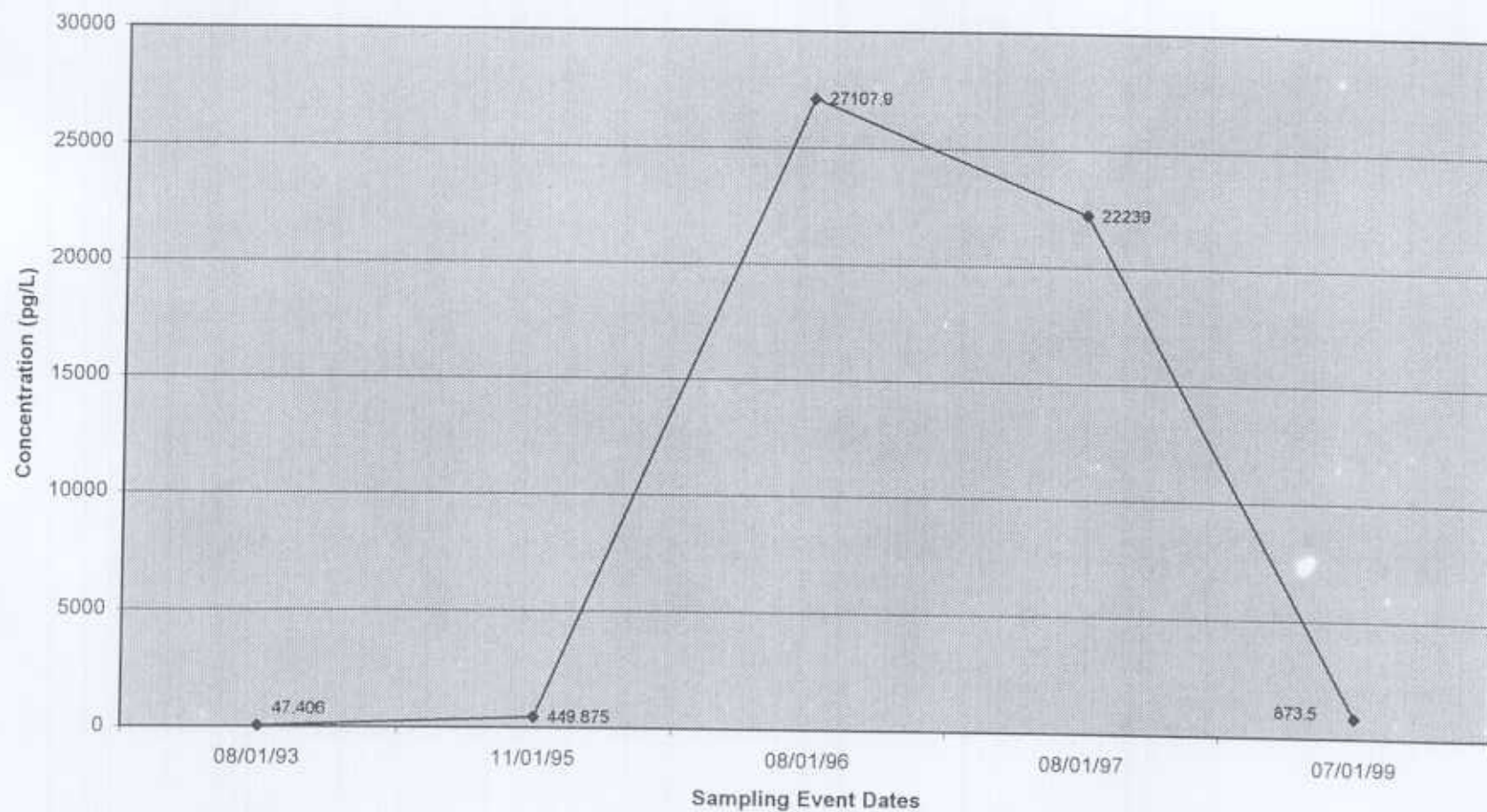
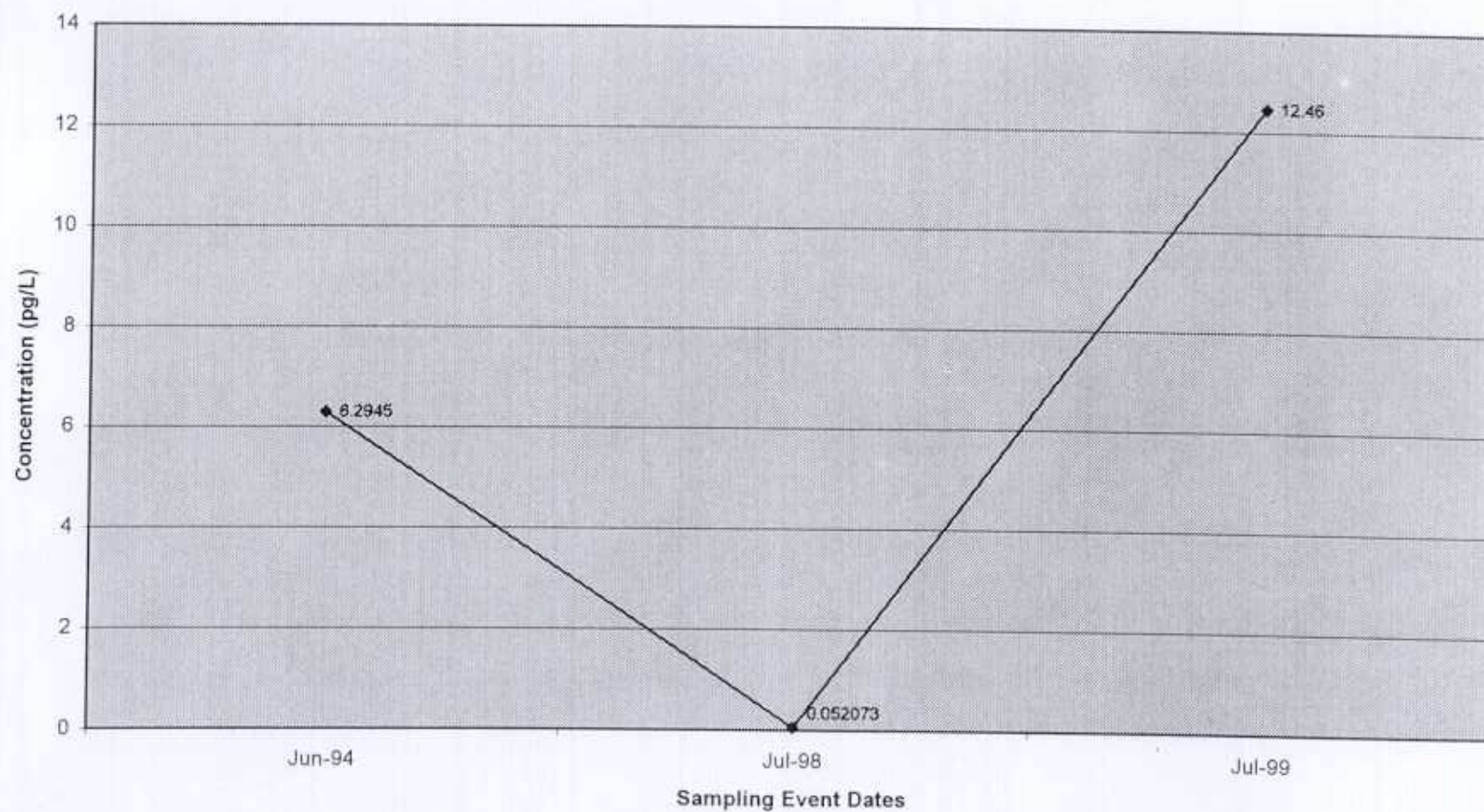


Figure 3-27
Well DSW-6C TCDD TEC



4.0 DATA QUALITY ASSURANCE SUMMARY

After review of the laboratory data deliverables, an evaluation was performed to determine how well the analytical portion of the project was executed and to what extent the chemical data achieved the project-specific data quality objectives. The precision, accuracy, representativeness, comparability, and completeness (PARCC) and the sensitivity were evaluated and are summarized in this section. Overall data quality was high and the data are acceptable for all project-specific purposes. In addition, all sample analyses were compliant with the project's approved sampling and analysis plan (SAP), which was included in the project management plan for the NAPL field exploration (USACE 1999a), except for the items discussed in the following subsections.

4.1 DATA QUALITY REVIEW METHODS

Data were reviewed in accordance with the project-specific criteria established in the SAP for the NAPL field exploration (in USACE 1999a) for the PARCC parameters, and validated in accordance with EPA's *Contract Laboratory Program National Functional Guidelines for Organic Data Review* (USEPA 1999) and *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (USEPA 1994). Results for the following laboratory confirmatory quality control (QC) samples were reviewed:

- Field and matrix duplicates
- Matrix spike/matrix spike duplicates (MS/MSD)
- Post-digestion spikes (metals only)
- Laboratory control samples (LCS) and blank spikes
- Performance evaluation (PE) samples (PAH/PCP and TPH-Dx only)
- Rinsate, field, and method blanks
- Surrogates (PAH/PCP, PCB, and TPH-Dx only)
- Internal standards (PAH/PCP and dioxin/furans only)
- Instrument tuning standards (PAH/PCP and dioxin/furans only)
- Initial and continuing calibration standards

Additionally, chain-of-custody (COC) and cooler receipt forms were reviewed, as part of sample representativeness, for evaluation of sample integrity during shipping and handling procedures, and to verify contractual and technical holding times. Laboratory reporting limits (i.e., sensitivity) were reviewed to determine if project-specific detection limits were met. Frequency of collection and analysis of field and laboratory QC samples was reviewed to evaluate completeness and adherence to the SAP.

Data quality review reports for sample delivery groups (SDGs) that were reviewed (i.e., desk-top and full data validation reports) are included in Appendix C. Data were reviewed by URS Greiner Woodward Clyde with the following exceptions:

- Soil TRPH data were reviewed by the USACE. The data quality review is included in the SCAPS report (USACE 1999b).
- Groundwater PAH/PCP data were reviewed by the U. S. EPA Region 9 Quality Assurance Program Office.
- Groundwater and soil dioxin/furans data were reviewed by DMD, Inc. of Vashon Island, Washington. Soil dioxin/furan data were not available for this draft report. Soil dioxin/furan data and validation reports will be included in the final report.

It should be noted that not all sample data associated with this site investigation were subjected to the data review process. Soil samples collected during the roto sonic boring and analyzed for TPH-Dx by the FASP laboratory were not reviewed because complete data reports were not available for review.

4.2 SUMMARY OF PRECISION, ACCURACY, REPRESENTATIVENESS, COMPARABILITY, AND COMPLETENESS, AND SENSITIVITY REVIEW FOR CHEMICAL ANALYSES

The desk-top and full data validation reports (Appendix C) were reviewed to identify trends in QC parameters that may impact overall data usability. Infrequent and random exceedances of QC limits are expected and do not necessarily limit data usability. General discussion of the QC exceedances and resulting data qualification are discussed in the following sections.

4.2.1 Precision

Precision examines the distribution of the reported values about their mean. The distribution of reported values refers to how different the individual reported values are from the average reported value. Precision may be affected by the natural variation of the matrix or contamination within that matrix, as well as by errors made in the field and/or laboratory handling procedures. Precision is evaluated using analyses of primary and field duplicate samples, laboratory MS/MSDs, and matrix duplicates (inorganics), which not only exhibit sampling and precision, but indicate precision through the reproducibility of the results. Relative percent difference (RPD) is used to evaluate precision. RPD QC limits for primary and field duplicate evaluation are ≤ 30 percent RPD for aqueous samples and ≤ 50 percent RPD for soil and NAPL samples. The RPD QC limits for MS/MSDs and matrix duplicates (MD) are those established by the

laboratories, and are referenced in the SAP (in USACE 1999). The data quality indicator “precision” was acceptable for this project.

The required frequency of field duplicate samples and laboratory MS/MSD/MDs are 10 percent and 5 percent, respectively, and were met with the following exception:

- The frequency of field duplicate soil samples for total petroleum hydrocarbon – diesel extended (TPH-Dx) was 9.6 percent.

Field duplicate results are presented in Tables 4-1 through 4-6. Exceedances are highlighted in bold. RPDs were generally within project-specific QC limits. Exceedances are likely due to one or more of the following analytical variances:

- High levels of target analytes in samples, which require secondary dilutions to bring the concentrations within the linear range of calibration (e.g., PAHs/PCP in soils). High dilution factors tend to cause RPD inaccuracies. Also, high levels of target analytes result in diluting out the matrix spike analytes.
- Sample heterogeneity for soil samples.
- Primary and field duplicate results at or near the limit of detection tend to have RPDs outside QC limits.

The analytical results did not require qualification based upon RPD exceedances, per EPA’s national functional guidelines for data review (USEPA 1999; USEPA 1994), except for the following incident. The soil samples analyzed for total organic carbon (SDG 99400) were estimated due to an elevated MD RPD.

4.2.2 Accuracy

Accuracy measures the analytical bias in a measurement system. Sources of error are the sampling process, field contamination, preservation, handling, nature of the sample matrix, sample preparation, and analysis techniques. Sampling and laboratory accuracy may be assessed by evaluating the results of equipment rinsate and method blanks, respectively. These data help to assess the potential contamination contribution from various sources. The laboratory objective for accuracy is to equal or exceed the accuracy demonstrated for the applied analytical methods on samples of the same matrix. The percent recovery criterion is used to estimate accuracy based on recovery in MS/MSDs, blank spikes, postdigestion spikes (PDSs), LCSs, PE samples, surrogates, internal standards, and calibration standards. The MS/MSDs, surrogates, and internal standards, which give an indication of matrix effects that may be affecting target

analytes, are also a good gauge of method efficiency. The data quality indicator “accuracy” was acceptable for this project.

The required frequency of these QC samples for collection and analysis were met except for the following exception:

- No equipment rinsate blank results were reported for polychlorinated biphenyls (PCBs). However, PCBs were not detected in the soil samples (SDG Nos. 99218B and 99221B).

The equipment rinsate blanks were free of contamination for all parameters. However, bis(2-ethylhexyl)phthalate (considered a common lab contaminant) and benzo(a)pyrene were detected in the method blank associated with the NAPL samples (SDG K9904956). Also, copper and/or zinc were detected in the method blanks associated with the soil samples (SDG 99273B and 99285D). Only the bis(2-ethylhexyl)phthalate results for the NAPL samples were qualified as nondetect. No further qualifications were required for benzo(a)pyrene, copper, and zinc because the sample results were >5 times the method blank concentrations.

MS/MSDs, blank spikes, PDSs, and LCSs were generally within project-specific QC limits. The only exceedance resulting in data qualification was the arsenic result for sample SB028-79.5-79.8, which was estimated due to an elevated PDS recovery. The organic analytical results did not require further qualification based upon MS/MSD, blank spike, and LCS exceedances, per EPA’s national functional guidelines for data review. Exceptions were due to one or more of the following analytical variances:

- Matrix spike analytes being diluted out due to the presence of high levels of target analytes in samples, which are the same analytes used for spiking the QC samples
- Sample heterogeneity for soil samples
- Presence of matrix interference

Ten blind PE samples (soil), five for TPH-Dx and five for polycyclic aromatic hydrocarbons/pentachlorophenol (PAH/PCP) analyses, were submitted to the EPA Region 9 Laboratories for this site investigation. The PE sample results were within QC limits, except for slightly elevated recoveries of anthracene, fluorene, and pyrene. It should be noted that if the laboratory used the proper number of significant figures (i.e., same as used for the QC limits), then additional results (i.e., benzo(a)pyrene) would be slightly above QC limits. The PE results are presented in Tables 4-7 and 4-8. The PE exceedances indicate that the detected sample results may be biased slightly high. However, it is not expected that the detected sample results would change by an order of magnitude. No qualifiers were recommended based on these PE exceedances.

Elevated surrogate recoveries were reported for several soil analyses (i.e., PCBs, TPH-Dx, and PAHs/PCP) and one NAPL analysis for semivolatiles, indicating high bias in the results. In accordance with the validation guidelines, only the positive results for the affected samples were qualified as estimated. The elevated surrogate recoveries may be due to the presence of matrix interference coeluting with surrogate compounds and/or the high levels of target analytes in the samples, resulting in secondary dilutions to bring the concentrations within the linear range of calibration. High dilution factors tend to cause surrogate recovery inaccuracies.

Surrogate recoveries were outside method QC limits for several water semivolatile analyses. Detected results were qualified as estimated and quantitation limits were qualified as rejected for numerous compounds in 6 of the 18 water samples analyzed.

Internal standards (ISs) were within method QC limits for PAH/PCP and semivolatile analyses, except for isolated instances where low IS recoveries were reported for initial sample analyses, which affect quantitation of naphthalene and 2-methylnaphthalene. Since the affected samples required secondary dilutions for these compounds and the IS recoveries were within QC limits, no qualification of the data were performed.

Due to low internal standard recoveries for semivolatiles analysis of water samples, several detected results were estimated and several quantitation limits were rejected.

Continuing calibrations associated with the PAH/PCP analyses of soils exhibited elevated percent differences for carbazole and/or pentachlorophenol. The affected PAH/PCP results were considered estimated. Instrument calibrations for all other analytes were within QC limits.

Continuing calibrations associated with the PAH/PCP analyses of waters exhibited elevated percent differences for benzyl alcohol, 2-methylphenol, 4-nitroaniline, 3-nitroaniline, carbazole, 3,3'-dichlorobenzidine, 2,2'-oxybis(1-chloropropane), and n-Nitroso-di-n-propylamine. and/or pentachlorophenol. The affected PAH/PCP results were considered estimated. Instrument calibrations for all other analytes were within QC limits.

Instrumental tuning and setup for the dioxin/furans water analyses were generally acceptable and within specification. Occasionally, mass spectral peaks exhibited tailing (less than optimal peak shape), which could indicate dirty optics and/or magnetic field fringe effects associated with less than optimal tuning during analysis of soils extracts. Gas chromatographic (GC) performance during analyses of water extracts showed considerable peak tailing and in the case of at least one sample (Q9602) GC performance was insufficient to permit reporting of some analytes (the reviewer carefully examined the data to provide estimated values). System cleanliness appeared to be responsible for less than optimal GC separation performance during the analysis of water extracts (peak shape degradation was also observed for method blank analyses). Some data were qualified as estimated due to degraded GC performance.

4.2.3 Representativeness

Representativeness expresses the degree to which the sample data accurately and precisely represent the characteristics of a population of samples, parameter variations at a sampling point, or environmental conditions. Representativeness is a qualitative parameter, which is most concerned with the proper design of the sampling program or subsampling of a given sample. Objectives for representativeness are defined for sampling and analysis tasks and are a function of the project-specific data quality objectives (DQOs). Sampling procedures, as described in the SAP have been selected with the goal of obtaining representative samples for the media of concern.

Representativeness is evaluated by examining sample tracking information and COC/cooler receipt documentation. This evaluation allows for contractual and technical holding times to be verified and also verifies that proper documentation was maintained to allow traceability of laboratory analytical results to specific field sample locations. Representativeness can also be assessed by evaluating the precision of matrix and field duplicates, as discussed in Section 1.2.1. The data quality indicator “representativeness” was acceptable for this project.

Sample integrity was generally maintained in accordance with SAP procedures, except for variances specifically referenced in Appendix C. Exceptions include:

- Cooler temperatures outside the QC limits of $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$
- Sample ID on the COC not in agreement with sample container
- PE samples incorrectly identified on COCs
- Sample not documented on COC, but the sample container was received by the laboratory and the appropriate analysis was performed
- COC not signed and dated by field relinquishing and/or laboratory receipt representatives
- Samples from the same location referenced twice on the same or on different COCs
- COC and cooler receipt form not submitted with analytical results (SDG 29326 and 29492 for geotechnical parameters)

- Sample container received broken at the laboratory; analysis unable to be performed
- Contractual and technical holding time exceedances (SDG 29392 for TOC)

Although all of the above referenced variances could potentially affect representativeness, the only variances which resulted in data qualification were contractual and technical holding time exceedances for soil TOC results for samples SB018-80.5-80.8, SB018-91.3-91.6, SB018-109.5-109.8, and SB018-183.4-183.7.

It is not expected that the cooler temperature exceedances (range from 0°C to 11.4°C) would adversely effect the sample results, because of the chemical nature of the project-specific analytes, i.e., PAHs/PCP, PCBs, and metals, are relatively stable and would not be expected to degrade significantly during sample transport.

Since the sample PE/sample ID discrepancies on the COCs were resolved between the laboratory and project personnel, these documentation discrepancies do not impact the reported analytical results.

4.2.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. This goal is achieved through using standard techniques to collect and analyze representative samples, and reporting analytical results in appropriate units. Complete field documentation using standardized data collection forms will support the assessment of comparability. Comparability is limited by other PARCC parameters, because only when precision and accuracy are known can data set comparison be performed with confidence. For data sets to be comparable, it is imperative that the analytical methods and procedures be strictly followed.

Comparability is evaluated by examining the laboratory analytical data and comparing the reported results for compliance with the project-specific approved methods and standard operating procedures (SOPs). The data review determined that the analytical results are acceptable for use, despite minor deviations from the methods and SOPs. The data quality indicator “comparability” was met by the laboratory(s) for this project.

Comparability is also evaluated by comparing inter-laboratory split sample results. However, split samples were not a project-specific requirement.

4.2.5 Completeness

Completeness is defined as a measure of the amount of valid data (usable for project-specific purposes) obtainable from a measurement system compared to the total amount of measurements expected to be obtained under normal conditions. It is important that appropriate QA procedures be maintained to ensure that valid data are obtained and the desired level of completeness meets the project-specific DQOs. For the data generated, the overall project-specific goal of 98 percent is required for completeness (or usability) of the analytical data. The overall completeness for this project is above 98 percent.

4.2.6 Sensitivity

The sensitivity (i.e., reporting limits) of the analytical methods is driven by the project-specific DQOs. All reporting limits met the project-specific requirements, except for some minor variances (i.e., PCBs for soils), as identified in Appendix C. It should be noted that several PAH/PCP soil samples required secondary dilutions, due to the presence of high levels of target analytes, which resulted in elevated reporting limits for nondetect analytes.

For dioxin/furan water concentrations, the laboratory reported lower quantitation limits as specified by both the method and the analytical service request. The reviewer recalculated lower quantitation limits and concentrations (with associated "J" qualifiers) in order to achieve project-specific objectives, which required 5 to 10 pg/L lower reporting limits for waters. The reported detection limits are estimates based on the assumption that linearity is preserved between the lowest calibration point and approximate 2.5 times the signal-to-noise ratio (as an instrumental detection limit). The reported detection and quantitation limits are considered acceptable for distinguishing the site from typical background and for comparison of site conditions to target thresholds.

4.3 OVERALL DATA USABILITY

After review of information contained in the laboratory data deliverables, an evaluation was performed to determine how well the analytical portion of the project was executed and to what extent the chemical data achieved the project-specific DQOs.

The overall DQO for this project was to generate data to support the following uses:

- Identify potential PCB contamination in the Cellon Process Area

- Identify the bottom of petroleum, oil, and lubricant (POL) and PAH/PCP contamination above site-specific threshold concentrations in the vadose zone, capillary fringe, and saturated zone
- Identify the chemical makeup and magnitude of NAPL at the site
- Identify the physical properties of the soils at the site
- Identify TOC levels from areas that have not been impacted by contamination
- Identify the natural attenuation potential and capacity of the groundwater system
- To determine levels of dioxin/furans and metals in soil from areas to be used for thermal treatment lab treatability studies
- Identify the boundary of the naphthalene plume

Data are intended primarily to be used for characterizing the creosote NAPL contamination and updating the site conceptual site model. Despite the minor data QC issues identified above and in Appendix C, the analytical data reported for this project are usable.

Table 4-1
Summary of Field Duplicate Results
PAH/PCP in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-006 C3 SB006-182.7-183 8/5/99 Primary	SB-006 C3 SB506-182.7-183 8/5/99 Field Duplicate	RPD	SB-007 C3 SB007-32.3-32.6 9/14/99 Primary	SB-007 C3 SB507-32.3-32.6 9/14/99 Field Duplicate	RPD	SB-018 C1 SB018-129.5-129.9 8/19/99 Primary	SB-018 C1 SB518-129.5-129.9 8/19/99 Field Duplicate	RPD
PAHs (mg/kg)									
2-methylnaphthalene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Acenaphthene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Acenaphthylene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Anthracene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(a)anthracene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(a)pyrene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(b)fluoranthene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(g,h,i)perylene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(k)fluoranthene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Carbazole	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Chrysene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Dibenzo(a,h)anthracene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Dibenzofuran	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Fluoranthene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Fluorene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Indeno(1,2,3-cd)pyrene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Naphthalene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Pentachlorophenol	60 U	60 U	--	60 U	60 U	--	50 U	50 U	--
Phenanthrene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--
Pyrene	30 U	30 U	--	20 U	20 U	--	20 U	20 U	--

Table 4-1 (Continued)
Summary of Field Duplicate Results
PAH/PCP in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-019 C2 SB019-37.4-37.7 8/12/99 Primary	SB-019 C2 SB519-37.4-37.7 8/12/99 Field Duplicate	RPD	SB-027 C2 SB027-61.0-61.4 9/2/99 Primary	SB-027 C2 SB527-61.0-61.4 9/2/99 Field Duplicate	RPD	SB-027 C2 SB527-142.3-143.0 9/3/99 Field Duplicate
PAHs (mg/kg)							
2-methylnaphthalene	20 U	20 U	--	20 U	20 U	--	20 U
Acenaphthene	20 U	20 U	--	20 U	20 U	--	20 U
Acenaphthylene	20 U	20 U	--	20 U	20 U	--	20 U
Anthracene	20 U	20 U	--	20 U	20 U	--	20 U
Benzo(a)anthracene	20 U	20 U	--	20 U	20 U	--	20 U
Benzo(a)pyrene	20 U	20 U	--	20 U	20 U	--	20 U
Benzo(b)fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U
Benzo(g,h,i)perylene	20 U	20 U	--	20 U	20 U	--	20 U
Benzo(k)fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U
Carbazole	20 U	20 U	--	20 U	20 U	--	20 U
Chrysene	20 U	20 U	--	20 U	20 U	--	20 U
Dibenzo(a,h)anthracene	20 U	20 U	--	20 U	20 U	--	20 U
Dibenzofuran	20 U	20 U	--	20 U	20 U	--	20 U
Fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U
Fluorene	20 U	20 U	--	20 U	20 U	--	20 U
Indeno(1,2,3-cd)pyrene	20 U	20 U	--	20 U	20 U	--	20 U
Naphthalene	20 U	20 U	--	20 U	20 U	--	20 U
Pentachlorophenol	60 U	60 U	--	60 U	50 U	--	60 U
Phenanthrene	20 U	20 U	--	20 U	20 U	--	20 U
Pyrene	20 U	20 U	--	20 U	20 U	--	20 U

Table 4-1 (Continued)
Summary of Field Duplicate Results
PAH/PCP in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-027 C2 SB027-214-214.5 9/7/99 Primary	SB-027 C2 SB527-214-214.5 9/7/99 Field Duplicate	RPD	SB-028 C2 SB028-53.5-55 9/29/99 Primary	SB-028 C2 SB528-53.5-55 9/29/99 Field Duplicate	RPD	SB-030 D3 SB030-121.4-122.2 8/23/99 Primary	SB-030 D3 SB530-121.4-122.2 8/23/99 Field Duplicate	RPD
PAHs (mg/kg)									
2-methylnaphthalene	20 U	20 U	--	420	650	43	30 U	20 U	--
Acenaphthene	20 U	20 U	--	260	450	54	30 U	20 U	--
Acenaphthylene	20 U	20 U	--	20 U	20 U	--	30 U	20 U	--
Anthracene	20 U	20 U	--	130	210	47	30 U	20 U	--
Benzo(a)anthracene	20 U	20 U	--	80	120	40	30 U	20 U	--
Benzo(a)pyrene	20 U	20 U	--	30	50	50	30 U	20 U	--
Benzo(b)fluoranthene	20 U	20 U	--	40	60	40	30 U	20 U	--
Benzo(g,h,i)perylene	20 U	20 U	--	10 J	20	67	30 U	20 U	--
Benzo(k)fluoranthene	20 U	20 U	--	30	40	29	30 U	20 U	--
Carbazole	20 UJ	20 UJ	--	70 J	100 J	35	30 U	20 U	--
Chrysene	20 U	20 U	--	70	110	44	30 U	20 U	--
Dibenzo(a,h)anthracene	20 U	20 U	--	20 U	20 U	--	30 U	20 U	--
Dibenzofuran	20 U	20 U	--	180	260	36	30 U	20 U	--
Fluoranthene	20 U	20 U	--	300	480	46	30 U	20 U	--
Fluorene	20 U	20 U	--	210	260	21	30 U	20 U	--
Indeno(1,2,3-cd)pyrene	20 U	20 U	--	10 J	20	67	30 U	20 U	--
Naphthalene	20 U	20 U	--	1200	1900	45	30 U	20 U	--
Pentachlorophenol	60 U	60 U	--	60 U	60 U	--	60 U	60 U	--
Phenanthrene	20 U	20 U	--	620	980	45	30 U	20 U	--
Pyrene	20 U	20 U	--	220	440	67	30 U	20 U	--

Table 4-1 (Continued)
Summary of Field Duplicate Results
PAH/PCP in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-047 D3 SB047-34.5-35.0 10/13/99 Primary	SB-047 D3 SB547-34.5-35.0 10/13/99 Field Duplicate	RPD	SB-051 D2 SB051-101.7-102.2 9/9/99 Primary	SB-051 D2 SB551-101.7-102.2 9/9/99 Field Duplicate	RPD	SB-052 D2 SB052-32.0-32.5 10/16/99 Primary	SB-052 D2 SB552-32.0-32.5 10/16/99 Field Duplicate	RPD
PAHs (mg/kg)									
2-methylnaphthalene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Acenaphthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Acenaphthylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Anthracene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(a)anthracene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(a)pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(b)fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(g,h,i)perylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(k)fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Carbazole	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Chrysene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Dibenzo(a,h)anthracene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Dibenzofuran	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Fluorene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Indeno(1,2,3-cd)pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Naphthalene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Pentachlorophenol	60 U	60 U	--	60 U	60 U	--	60 U	60 U	--
Phenanthrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--

Table 4-1 (Continued)
Summary of Field Duplicate Results
PAH/PCP in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-052 D2 SB052-118.5-119 10/17/99 Primary	SB-052 D2 SB552-118.5-119 10/17/99 Field Duplicate	RPD	SB-057 C2 SB057-36-38 10/9/99 Primary	SB-057 C2 SB557-36-38 10/9/99 Field Duplicate	RPD	SB-057 C2 SB057-51-52 10/9/99 Primary	SB-057 C2 SB557-51-52 10/9/99 Field Duplicate	RPD
PAHs (mg/kg)									
2-methylnaphthalene	20 U	20 U	--	1400	2500	56	80	100	22
Acenaphthene	20 U	20 U	--	600	900	40	50	60	18
Acenaphthylene	20 U	20 U	--	10 J	20	67	20 U	20 U	--
Anthracene	20 U	20 U	--	230	400	54	20	30	40
Benzo(a)anthracene	20 U	20 U	--	50	90	57	20 U	20 U	--
Benzo(a)pyrene	20 U	20 U	--	20	20	0	20 U	20 U	--
Benzo(b)fluoranthene	20 U	20 U	--	10 J	20	67	20 U	20 U	--
Benzo(g,h,i)perylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(k)fluoranthene	20 U	20 U	--	20	20	0	20 U	20 U	--
Carbazole	20 UJ	20 UJ	--	80 J	130 J	48	20 UJ	20 UJ	--
Chrysene	20 U	20 U	--	50	90	57	20 U	20 U	--
Dibenzo(a,h)anthracene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Dibenzofuran	20 U	20 U	--	300	600	67	30	40	29
Fluoranthene	20 U	20 U	--	300	500	50	30	40	29
Fluorene	20 U	20 U	--	400	700	54	40	40	0
Indeno(1,2,3-cd)pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Naphthalene	20 U	20 U	--	3100	5400	54	110	130	17
Pentachlorophenol	50 U	60 U	--	130	200 J	42	60 U	60 U	-
Phenanthrene	20 U	20 U	--	800	1300	48	80	100	22
Pyrene	20 U	20 U	--	220	400	58	30	30	0

Table 4-1 (Continued)
Summary of Field Duplicate Results
PAH/PCP in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-057 C2 SB057-65-66 10/9/99 Primary	SB-057 C2 SB557-65-66 10/9/99 Field Duplicate	RPD	SB-061 D2 SB061-154.0-154.4 8/31/99 Primary	SB-061 D2 SB561-154.0-154.4 8/31/99 Field Duplicate	RPD	SB-084 C1 SB084-135.6-136 9/18/99 Primary	SB-084 C1 SB584-135.6-136 9/18/99 Field Duplicate	RPD
PAHs (mg/kg)									
2-methylnaphthalene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Acenaphthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Acenaphthylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Anthracene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(a)anthracene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(a)pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(b)fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(g,h,i)perylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(k)fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Carbazole	20 UJ	20 UJ	--	20 U	20 U	--	20 UJ	20 UJ	--
Chrysene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Dibenzo(a,h)anthracene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Dibenzofuran	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Fluorene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Indeno(1,2,3-cd)pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Naphthalene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Pentachlorophenol	60 U	60 U	--	60 U	60 U	--	60 U	60 U	--
Phenanthrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--

Table 4-1 (Continued)
Summary of Field Duplicate Results
PAH/PCP in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-084 C1 SB084-226.0-226.5 9/19/99 Primary	SB-084 C1 SB584-226.0-226.5 9/19/99 Field Duplicate	RPD	SB-086 C1 SB086-27-28.5 9/28/99 Primary	SB-086 C1 SB586-27-28.5 9/28/99 Field Duplicate	RPD	SB-092 C3 SB092-86.0-86.5 9/20/99 Primary	SB-092 C3 SB592-86.0-86.5 9/20/99 Field Duplicate	RPD
PAHs (mg/kg)									
2-methylnaphthalene	20 U	20 U	--	300	240	22	20 U	20 U	--
Acenaphthene	20 U	20 U	--	190	160	17	20 U	20 U	--
Acenaphthylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Anthracene	20 U	20 U	--	100	90	11	20 U	20 U	--
Benzo(a)anthracene	20 U	20 U	--	40	30	29	20 U	20 U	--
Benzo(a)pyrene	20 U	20 U	--	10 J	20 U	--	20 U	20 U	--
Benzo(b)fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(g,h,i)perylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(k)fluoranthene	20 U	20 U	--	10 J	10 J	0	20 U	20 U	--
Carbazole	20 UJ	20 UJ	--	50	40	22	20 UJ	20 UJ	--
Chrysene	20 U	20 U	--	40	30	29	20 U	20 U	--
Dibenzo(a,h)anthracene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Dibenzofuran	20 U	20 U	--	110	100	10	20 U	20 U	--
Fluoranthene	20 U	20 U	--	170	140	19	20 U	20 U	--
Fluorene	20 U	20 U	--	150	120	22	20 U	20 U	--
Indeno(1,2,3-cd)pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Naphthalene	20 U	20 U	--	1200	900	29	20 U	20 U	--
Pentachlorophenol	60 U	60 U	--	60 U	60 U	--	60 U	60 U	--
Phenanthrene	20 U	20 U	--	400	300	29	20 U	20 U	--
Pyrene	20 U	20 U	--	140	120	15	20 U	20 U	--

Table 4-1 (Continued)
Summary of Field Duplicate Results
PAH/PCP in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-092 C3 SB092-131.0-131.5 9/21/99 Primary	SB-092 C3 SB592-131.0-131.5 9/21/99 Field Duplicate	RPD	SB-099 C3 SB099-3.1-4.6 9/30/99 Primary	SB-099 C3 SB599-3.1-4.6 9/30/99 Field Duplicate	RPD	SB-099 C3 SB099-27.5-29.5 9/30/99 Primary	SB-099 C3 SB599-27.5-29.5 9/30/99 Field Duplicate	RPD
PAHs (mg/kg)									
2-methylnaphthalene	20 U	20 U	--	60	140	80	800	700	13
Acenaphthene	20 U	20 U	--	40	80	67	1000	1000	0
Acenaphthylene	20 U	20 U	--	40 U	40 U	--	30 J	30 J	0
Anthracene	20 U	20 U	--	110	110	0	350	340	3
Benzo(a)anthracene	20 U	20 U	--	40	40	0	170	150	12
Benzo(a)pyrene	20 U	20 U	--	30 J	30 J	0	50	50	0
Benzo(b)fluoranthene	20 U	20 U	--	40	40	0	40 J	40 J	0
Benzo(g,h,i)perylene	20 U	20 U	--	40 U	40 U	--	50 U	50 U	--
Benzo(k)fluoranthene	20 U	20 U	--	40	20 J	67	50	50	0
Carbazole	20 UJ	20 UJ	--	50 J	50 J	0	180 J	180 J	0
Chrysene	20 U	20 U	--	60	60	0	170	160	6
Dibenzo(a,h)anthracene	20 U	20 U	--	40 U	40 U	--	50 U	50 U	--
Dibenzofuran	20 U	20 U	--	20 J	40	67	540	500	8
Fluoranthene	20 U	20 U	--	160	170	6	900	900	0
Fluorene	20 U	20 U	--	30 J	60	67	800	800	0
Indeno(1,2,3-cd)pyrene	20 U	20 U	--	20 J	40 U	--	50 U	50 U	--
Naphthalene	20 U	20 U	--	200	440	75	2,000	1,900	5
Pentachlorophenol	60 U	60 U	--	100	200	67	100 U	100 U	--
Phenanthrene	20 U	20 U	--	150	180	18	2,000	2,000	0
Pyrene	20 U	20 U	--	140	160	13	800	700	13

Table 4-1 (Continued)
Summary of Field Duplicate Results
PAH/PCP in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-099 C3 SB099-127.3-127.5 10/7/99 Primary	SB-099 C3 SB599-127.3-127.5 10/7/99 Field Duplicate	RPD	SB-099 C3 SB099-160.7-160.9 10/7/99 Primary	SB-099 C3 SB599-160.7-160.9 10/7/99 Field Duplicate	RPD	SE-002 C1 SS002-84-86 7/15/99 Primary	SE-002 C1 SS502-84-86 7/15/99 Field Duplicate	RPD
PAHs (mg/kg)									
2-methylnaphthalene	20 U	20 U	--	200	190	5	20 U	20 U	--
Acenaphthene	20 U	20 U	--	110	120	9	20 U	20 U	--
Acenaphthylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Anthracene	20 U	20 U	--	40	50	22	20 U	20 U	--
Benzo(a)anthracene	20 U	20 U	--	20	30	40	20 U	20 U	--
Benzo(a)pyrene	20 U	20 U	--	10 J	10 J	0	20 U	20 U	--
Benzo(b)fluoranthene	20 U	20 U	--	10 J	10 J	0	20 U	20 U	--
Benzo(g,h,i)perylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(k)fluoranthene	20 U	20 U	--	10 J	10 J	0	20 U	20 U	--
Carbazole	20 UJ	20 UJ	--	10 J	10 J	0	20 U	20 U	--
Chrysene	20 U	20 U	--	20	30	40	20 U	20 U	--
Dibenzo(a,h)anthracene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Dibenzofuran	20 U	20 U	--	70	80	13	20 U	20 U	--
Fluoranthene	20 U	20 U	--	100	110	10	20 U	20 U	--
Fluorene	20 U	20 U	--	80	90	12	20 U	20 U	--
Indeno(1,2,3-cd)pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Naphthalene	20 U	20 U	--	380	310	20	20 U	20 U	--
Pentachlorophenol	60 U	60 U	--	60 U	50 U	--	20 U	20 U	--
Phenanthrene	20 U	20 U	--	190	220	15	20 U	20 U	--
Pyrene	20 U	20 U	--	80	90	12	20 U	20 U	--

Table 4-1 (Continued)
Summary of Field Duplicate Results
PAH/PCP in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SE-008 C2 SS008-10.5-11.7 8/8/99 Primary	SE-003 C2 SS508-10.5-11.7 8/8/99 Field Duplicate	RPD	SE-020 C2 SS020-29-31 8/8/99 Primary	SE-020 C2 SS520-29-31 8/8/99 Field Duplicate	RPD	SE-020 C2 SS020-56-58 8/8/99 Primary	SE-020 C2 SS520-56-58 8/8/99 Field Duplicate	RPD
PAHs (mg/kg)									
2-methylnaphthalene	20 U	20 U	--	370	180	69	540	600	11
Acenaphthene	20 U	20 U	--	140	80	55	240	270	12
Acenaphthylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Anthracene	20 U	20 U	--	60	40	40	100	110	10
Benzo(a)anthracene	20 U	20 U	--	10 J	20 U	--	20	30	40
Benzo(a)pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(b)fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(g,h,i)perylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(k)fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Carbazole	20 U	20 U	--	20	20 U	--	40	40	0
Chrysene	20 U	20 U	--	10 J	20 U	--	30	30	0
Dibenzo(a,h)anthracene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Dibenzofuran	20 U	20 U	--	100	50	67	140	160	13
Fluoranthene	20 U	20 U	--	80	50	46	130	140	7
Fluorene	20 U	20 U	--	100	60	50	160	180	12
Indeno(1,2,3-cd)pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Naphthalene	20 J	20 J	--	620	320	64	1000	1300	26
Pentachlorophenol	60 J	30 J	--	60 U	60 U	--	60	60	0
Phenanthrene	20 U	20 U	--	200	130	42	380	400	5
Pyrene	20 U	20 U	--	60	40	40	110	120	9

Table 4-1 (Continued)
Summary of Field Duplicate Results
PAH/PCP in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SE-043 D2 SS043-23-25 8/9/99 Primary	SE-043 D2 SS543-23-25 8/9/99 Field Duplicate	RPD	SE-064 C2 SS064-34-36 9/6/99 Primary	SE-064 C2 SS564-34-36 9/6/99 Field Duplicate	RPD	SE-088 B1 SS088-24-25.8 9/6/99 Primary	SE-088 B1 SS588-24-25.8 9/6/99 Field Duplicate	RPD
PAHs (mg/kg)									
2-methylnaphthalene	20 U	20 U	--	210	220	5	250	280	11
Acenaphthene	20 U	20 U	--	130	120	8	170	180	6
Acenaphthylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Anthracene	20 U	20 U	--	50	40	22	80	80	0
Benzo(a)anthracene	20 U	20 U	--	10 J	20 U	--	20	20	0
Benzo(a)pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(b)fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(g,h,i)perylene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Benzo(k)fluoranthene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Carbazole	20 U	20 U	--	20 UJ	20 UJ	--	40 J	40 J	0
Chrysene	20 U	20 U	--	10 J	20 U	--	20	20	0
Dibenzo(a,h)anthracene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Dibenzofuran	20 U	20 U	--	80	70	13	110	120	9
Fluoranthene	20 U	20 U	--	70	60	15	120	120	0
Fluorene	20 U	20 U	--	90	80	12	130	140	7
Indeno(1,2,3-cd)pyrene	20 U	20 U	--	20 U	20 U	--	20 U	20 U	--
Naphthalene	20 U	20 U	--	290	350	19	510 J	550	8
Pentachlorophenol	60 U	60 U	--	60 U	60 U	--	60 U	60 U	--
Phenanthrene	20 U	20 U	--	180	160	12	290	310	7
Pyrene	20 U	20 U	--	60	50	18	90	100	11

Table 4-1 (Continued)
Summary of Field Duplicate Results
PAH/PCP in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SE-097 D2 SS097-92.6-94 9/7/99 Primary	SE-097 D2 SS597-92.6-94 9/7/99 Field Duplicate	RPD
PAHs (mg/kg)			
2-methylnaphthalene	30 U	10 J	--
Acenaphthene	30 U	30 U	--
Acenaphthylene	30 U	30 U	--
Anthracene	30 U	30 U	--
Benzo(a)anthracene	30 U	30 U	--
Benzo(a)pyrene	30 U	30 U	--
Benzo(b)fluoranthene	30 U	30 U	--
Benzo(g,h,i)perylene	30 U	30 U	--
Benzo(k)fluoranthene	30 U	30 U	--
Carbazole	30 UJ	30 UJ	--
Chrysene	30 U	30 U	--
Dibenzo(a,h)anthracene	30 U	30 U	--
Dibenzofuran	30 U	30 U	--
Fluoranthene	30 U	30 U	--
Fluorene	30 U	30 U	--
Indeno(1,2,3-cd)pyrene	30 U	30 U	--
Naphthalene	30 U	20 J	--
Pentachlorophenol	60 U	60 U	--
Phenanthrene	20 J	20 J	0
Pyrene	30 U	30 U	--
TOTAL HPAH (U=1/2)	150	150	--
TOTAL LPAH (U=1/2)	110	110	--
TOTAL PAH (U=1/2)	260	260	--
LPAH/HPAY (U=1/2)	0.73	0.73	--
Naphthalene/Total PAH (U=1/2)	0.12	0.07 U	--

Notes:

J - estimated value

U - not detected at or above associated value

-- value not calculated

Table 4-2
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-004 D2 SB004-149.7-150 8/10/99 Primary	SB-004 D2 SB504-149.7-150 8/10/99 Field Duplicate	RPD	SB-006 C3 SB006-102 8/4/99 Primary	SB-006 C3 SB506-102 8/4/99 Field Duplicate	RPD	SB-006 C3 SB006-182.7-183 8/5/99 Primary	SB-006 C3 SB506-182.7-183 8/5/99 Field Duplicate	RPD
TPH (mg/kg)									
TRPH	--	--	--	--	--	--	--	--	--
Total hydrocarbons, C10-C39	100 U	100 U	--	100 U	100 U	--	100 U	100 U	--
C10-C11	--	--	--	--	--	--	--	--	--
C12-C13	--	--	--	--	--	--	--	--	--
C14-C15	--	--	--	--	--	--	--	--	--
C16-C17	--	--	--	--	--	--	--	--	--
C18-C19	--	--	--	--	--	--	--	--	--
C20-C21	--	--	--	--	--	--	--	--	--
C22-C23	--	--	--	--	--	--	--	--	--
C24-C25	--	--	--	--	--	--	--	--	--
C27-C28	--	--	--	--	--	--	--	--	--
C29-C30	--	--	--	--	--	--	--	--	--
C31-C32	--	--	--	--	--	--	--	--	--
C33-C34	--	--	--	--	--	--	--	--	--
C35-C36	--	--	--	--	--	--	--	--	--
C37-C39	--	--	--	--	--	--	--	--	--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-007 C3 SB007-32.3-32.6 9/14/99 Primary	SB-007 C3 SB507-32.3-32.6 9/14/99 Field Duplicate	RPD	SB-007 C3 SB007-116.3-116.6 9/15/99 Primary	SB-007 C3 SB507-116.3-117.3 9/15/99 Field Duplicate	RPD	SB-007 C3 SB007-180.5-181.0 9/16/99 Primary	SB-007 C3 SB507-180.5-181.0 9/16/99 Field Duplicate	RPD
TPH (mg/kg)									
TRPH	--	--	--	--	--	--	--	--	--
Total hydrocarbons, C10-C39	100 U	100 U	--	100 U	100 U	--	100 U	100 U	--
C10-C11	--	--	--	--	--	--	--	--	--
C12-C13	--	--	--	--	--	--	--	--	--
C14-C15	--	--	--	--	--	--	--	--	--
C16-C17	--	--	--	--	--	--	--	--	--
C18-C19	--	--	--	--	--	--	--	--	--
C20-C21	--	--	--	--	--	--	--	--	--
C22-C23	--	--	--	--	--	--	--	--	--
C24-C25	--	--	--	--	--	--	--	--	--
C27-C28	--	--	--	--	--	--	--	--	--
C29-C30	--	--	--	--	--	--	--	--	--
C31-C32	--	--	--	--	--	--	--	--	--
C33-C34	--	--	--	--	--	--	--	--	--
C35-C36	--	--	--	--	--	--	--	--	--
C37-C39	--	--	--	--	--	--	--	--	--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-018 C1 SB018-129.5-129.9 8/19/99 Primary	SB-018 C1 SB518-129.5-129.9 8/19/99 Field Duplicate	RPD	SB-019 C2 SB019-37.4-37.7 8/12/99 Primary	SB-019 C2 SB519-37.4-37.7 8/12/99 Field Duplicate	RPD	SB-019 C2 SB519-137.0-137.3 8/13/99 Field Duplicate
TPH (mg/kg)							
TRPH	--	--	--	151	99	42	--
Total hydrocarbons, C10-C39	100 U	100 U	--	88 J	120	31	100 U
C10-C11	--	--	--	--	--	--	--
C12-C13	--	--	--	6	12	67	--
C14-C15	--	--	--	21	29	32	--
C16-C17	--	--	--	27	28	4	--
C18-C19	--	--	--	13	25	63	--
C20-C21	--	--	--	19	26	31	--
C22-C23	--	--	--	--	--	--	--
C24-C25	--	--	--	--	--	--	--
C27-C28	--	--	--	--	--	--	--
C29-C30	--	--	--	--	--	--	--
C31-C32	--	--	--	--	--	--	--
C33-C34	--	--	--	--	--	--	--
C35-C36	--	--	--	--	--	--	--
C37-C39	--	--	--	--	--	--	--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-025 C2 SB025-163.0-163.4 8/27/99 Primary	SB-025 C2 SB525-163.0-163.4 8/27/99 Field Duplicate	RPD	SB-027 C2 SB027-61.0-61.4 9/2/99 Primary	SB-027 C2 SB527-61.0-61.4 9/2/99 Field Duplicate	RPD	SB-027 C2 SB027-142.3-143.0 9/3/99 Primary	SB-027 C2 SB527-142.3-143.0 9/3/99 Field Duplicate	RPD
TPH (mg/kg)									
TRPH	--	--	--	--	--	--	--	--	--
Total hydrocarbons, C10-C39	100 U	100 U	--	100 U	100 U	--	100 U	100 U	--
C10-C11	--	--	--	--	--	--	--	--	--
C12-C13	--	--	--	--	--	--	--	--	--
C14-C15	--	--	--	--	--	--	--	--	--
C16-C17	--	--	--	--	--	--	--	--	--
C18-C19	--	--	--	--	--	--	--	--	--
C20-C21	--	--	--	--	--	--	--	--	--
C22-C23	--	--	--	--	--	--	--	--	--
C24-C25	--	--	--	--	--	--	--	--	--
C27-C28	--	--	--	--	--	--	--	--	--
C29-C30	--	--	--	--	--	--	--	--	--
C31-C32	--	--	--	--	--	--	--	--	--
C33-C34	--	--	--	--	--	--	--	--	--
C35-C36	--	--	--	--	--	--	--	--	--
C37-C39	--	--	--	--	--	--	--	--	--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-027 C2 SB027-214-214.5 9/7/99 Primary	SB-027 C2 SB527-214-214.5 9/7/99 Field Duplicate	RPD	SB-028 C2 SB028-53.5-55 9/29/99 Primary	SB-028 C2 SB528-53.5-55 9/29/99 Field Duplicate	RPD	SB-030 D3 SB030-121.4-122.2 8/23/99 Primary	SB-030 D3 SB530-121.4-122.2 8/23/99 Field Duplicate	RPD
TPH (mg/kg)									
TRPH	--	--	--	--	--	--	--	--	--
Total hydrocarbons, C10-C39	100 U	100 U	--	6000	6500	8	100 U	100 U	--
C10-C11	--	--	--	1700	1800	6	--	--	--
C12-C13	--	--	--	820	900	9	--	--	--
C14-C15	--	--	--	980	1100	12	--	--	--
C16-C17	--	--	--	900	980	9	--	--	--
C18-C19	--	--	--	620	670	8	--	--	--
C20-C21	--	--	--	460	500	8	--	--	--
C22-C23	--	--	--	240	260	8	--	--	--
C24-C25	--	--	--	97	100	3	--	--	--
C27-C28	--	--	--	130	140	7	--	--	--
C29-C30	--	--	--	57	63	10	--	--	--
C31-C32	--	--	--			--	--	--	--
C33-C34	--	--	--			--	--	--	--
C35-C36	--	--	--			--	--	--	--
C37-C39	--	--	--			--	--	--	--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-047 D3 SB547-28.7-29.0 10/13/99 Field Duplicate	SB-047 D3 SB047-34.5-35.0 10/13/99 Primary	SB-047 D3 SB547-34.5-35.0 10/13/99 Field Duplicate	RPD	SB-047 D3 SB047-129.5-130.0 10/14/99 Primary	SB-047 D3 SB547-129.5-130.0 10/14/99 Field Duplicate	RPD
TPH (mg/kg)							
TRPH	--	--	--	--	--	--	--
Total hydrocarbons, C10-C39	100 U	100 U	100 U	--	100 U	100 U	--
C10-C11	--	--	--	--	--	--	--
C12-C13	--	--	--	--	--	--	--
C14-C15	--	--	--	--	--	--	--
C16-C17	--	--	--	--	--	--	--
C18-C19	--	--	--	--	--	--	--
C20-C21	--	--	--	--	--	--	--
C22-C23	--	--	--	--	--	--	--
C24-C25	--	--	--	--	--	--	--
C27-C28	--	--	--	--	--	--	--
C29-C30	--	--	--	--	--	--	--
C31-C32	--	--	--	--	--	--	--
C33-C34	--	--	--	--	--	--	--
C35-C36	--	--	--	--	--	--	--
C37-C39	--	--	--	--	--	--	--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-047 D3 SB047-188.0-188.5 10/15/99 Primary	SB-047 D3 SB547-188.0-188.5 10/15/99 Field Duplicate	RPD	SB-051 D2 SB051-101.7-102.2 9/9/99 Primary	SB-051 D2 SB551-101.7-102.2 9/9/99 Field Duplicate	RPD	SB-051 D2 SB051-152.7-153.0 9/13/99 Primary	SB-051 D2 SB551-152.7-153.0 9/13/99 Field Duplicate	RPD
TPH (mg/kg)									
TRPH	--	--	--	--	--	--	--	--	--
Total hydrocarbons, C10-C39	100 U	100 U	--	100 U	100 U	--	100 U	100 U	--
C10-C11	--	--	--	--	--	--	--	--	--
C12-C13	--	--	--	--	--	--	--	--	--
C14-C15	--	--	--	--	--	--	--	--	--
C16-C17	--	--	--	--	--	--	--	--	--
C18-C19	--	--	--	--	--	--	--	--	--
C20-C21	--	--	--	--	--	--	--	--	--
C22-C23	--	--	--	--	--	--	--	--	--
C24-C25	--	--	--	--	--	--	--	--	--
C27-C28	--	--	--	--	--	--	--	--	--
C29-C30	--	--	--	--	--	--	--	--	--
C31-C32	--	--	--	--	--	--	--	--	--
C33-C34	--	--	--	--	--	--	--	--	--
C35-C36	--	--	--	--	--	--	--	--	--
C37-C39	--	--	--	--	--	--	--	--	--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-052 D2 SB052-32.0-32.5 10/16/99 Primary	SB-052 D2 SB552-32.0-32.5 10/16/99 Field Duplicate	RPD	SB-052 D2 SB052-118.5-119 10/17/99 Primary	SB-052 D2 SB552-118.5-119 10/17/99 Field Duplicate	RPD	SB-052 D2 SB052-175.5-176.0 10/18/99 Primary	SB-052 D2 SB552-175.5-176 10/18/99 Field Duplicate	RPD
TPH (mg/kg)									
TRPH	--	--	--	--	--	--	--	--	--
Total hydrocarbons, C10-C39	100 U	100 U	--	100 U	100 U	--	90 U	100 U	--
C10-C11	--	--	--	--	--	--	--	--	--
C12-C13	--	--	--	--	--	--	--	--	--
C14-C15	--	--	--	--	--	--	--	--	--
C16-C17	--	--	--	--	--	--	--	--	--
C18-C19	--	--	--	--	--	--	--	--	--
C20-C21	--	--	--	--	--	--	--	--	--
C22-C23	--	--	--	--	--	--	--	--	--
C24-C25	--	--	--	--	--	--	--	--	--
C27-C28	--	--	--	--	--	--	--	--	--
C29-C30	--	--	--	--	--	--	--	--	--
C31-C32	--	--	--	--	--	--	--	--	--
C33-C34	--	--	--	--	--	--	--	--	--
C35-C36	--	--	--	--	--	--	--	--	--
C37-C39	--	--	--	--	--	--	--	--	--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-057 C2 SB057-36-38 10/9/99 Primary	SB-057 C2 SB557-36-38 10/9/99 Field Duplicate	RPD	SB-057 C2 SB057-51-52 10/9/99 Primary	SB-057 C2 SB557-51-52 10/9/99 Field Duplicate	RPD	SB-061 D2 SB061-154.0-154.4 8/31/99 Primary	SB-061 D2 SB561-154.0-154.4 8/31/99 Field Duplicate	RPD
TPH (mg/kg)									
TRPH	--	--	--	--	--	--	--	--	--
Total hydrocarbons, C10-C39	30000	15000	67	2000	1500	29	100 U	100 U	--
C10-C11	8000	4100	64	490	350	33	--	--	--
C12-C13	6800	3500	64	440	340	26	--	--	--
C14-C15	6700	3600	60	430	340	23	--	--	--
C16-C17	3900	2000	64	290	230	23	--	--	--
C18-C19	2100	980	73	200	140	35	--	--	--
C20-C21	1400	1000	33	120	89	30	--	--	--
C22-C23	590		--	49	38	25	--	--	--
C24-C25	270		--	22	18	20	--	--	--
C27-C28	200		--	12		--	--	--	--
C29-C30			--			--	--	--	--
C31-C32			--			--	--	--	--
C33-C34			--			--	--	--	--
C35-C36			--			--	--	--	--
C37-C39			--			--			--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-084 C1 SB084-135.6-136 9/18/99 Primary	SB-084 C1 SB584-135.6-136 9/18/99 Field Duplicate	RPD	SB-084 C1 SB084-226.0-226.5 9/19/99 Primary	SB-084 C1 SB584-226.0-226.5 9/19/99 Field Duplicate	RPD	SB-086 C1 SB086-27-28.5 9/28/99 Primary	SB-086 C1 SB586-27-28.5 9/28/99 Field Duplicate	RPD
TPH (mg/kg)									
TRPH	--	--	--	--	--	--	--	--	--
Total hydrocarbons, C10-C39	100 U	100 U	--	100 U	100 U	--	4600	7700	50
C10-C11	--	--	--	--	--	--	1500	2200	38
C12-C13	--	--	--	--	--	--	590	1000	52
C14-C15	--	--	--	--	--	--	740	1300	55
C16-C17	--	--	--	--	--	--	690	1200	54
C18-C19	--	--	--	--	--	--	510	920	57
C20-C21	--	--	--	--	--	--	320	580	58
C22-C23	--	--	--	--	--	--	150	250	50
C24-C25	--	--	--	--	--	--	41	110	91
C27-C28	--	--	--	--	--	--	34	63	60
C29-C30	--	--	--	--	--	--		27	--
C31-C32	--	--	--	--	--	--			--
C33-C34	--	--	--	--	--	--			--
C35-C36	--	--	--	--	--	--			--
C37-C39	--	--	--	--	--	--			--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-092 C3 SB092-86.0-86.5 9/20/99 Primary	SB-092 C3 SB592-86.0-86.5 9/20/99 Field Duplicate	RPD	SB-092 C3 SB092-131.0-131.5 9/21/99 Primary	SB-092 C3 SB592-131.0-131.5 9/21/99 Field Duplicate	RPD	SB-099 C3 SB099-3.1-4.6 9/30/99 Primary	SB-099 C3 SB599-3.1-4.6 9/30/99 Field Duplicate	RPD
TPH (mg/kg)									
TRPH	--	--	--	--	--	--	--	--	--
Total hydrocarbons, C10-C39	100 U	100 U	--	100 U	100 U	--	2100	6200	99
C10-C11	--	--	--	--	--	--	300	300	0
C12-C13	--	--	--	--	--	--	230	170	30
C14-C15	--	--	--	--	--	--	290	300	3
C16-C17	--	--	--	--	--	--	250	490	65
C18-C19	--	--	--	--	--	--	260	880	109
C20-C21	--	--	--	--	--	--	200	890	127
C22-C23	--	--	--	--	--	--	200	940	130
C24-C25	--	--	--	--	--	--	140	680	132
C27-C28	--	--	--	--	--	--	130	630	132
C29-C30	--	--	--	--	--	--	110	600	138
C31-C32	--	--	--	--	--	--		90	--
C33-C34	--	--	--	--	--	--	23	150	147
C35-C36	--	--	--	--	--	--		44	--
C37-C39	--	--	--	--	--	--		49	--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-099 C3 SB099-27.5-29.5 9/30/99 Primary	SB-099 C3 SB599-27.5-29.5 9/30/99 Field Duplicate	RPD	SB-099 C3 SB099-127.3-127.5 10/7/99 Primary	SB-099 C3 SB599-127.3-127.5 10/7/99 Field Duplicate	RPD	SB-099 C3 SB099-160.7-160.9 10/7/99 Primary	SB-099 C3 SB599-160.7-160.9 10/7/99 Field Duplicate	RPD
TPH (mg/kg)									
TRPH	--	--	--	--	--	--	--	--	--
Total hydrocarbons, C10-C39	18000	22000	20	100 U	100 U	--	1200	2200	59
C10-C11	2100	2600	21	--	--	--	320	560	55
C12-C13	1500	2000	29	--	--	--	210	370	55
C14-C15	3400	4300	23	--	--	--	210	370	55
C16-C17	3700	4600	22	--	--	--	160	290	58
C18-C19	3100	3900	23	--	--	--	110	200	58
C20-C21	2100	2600	21	--	--	--	88	160	58
C22-C23	720	930	25	--	--	--	47	77	48
C24-C25	620	820	28	--	--	--	13	44	109
C27-C28	390	520	29	--	--	--	22	50	78
C29-C30			--	--	--	--	6	19	104
C31-C32			--	--	--	--			--
C33-C34			--	--	--	--			--
C35-C36			--	--	--	--			--
C37-C39			--	--	--	--			--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SE-002 C1 SS002-84-86 7/15/99 Primary	SE-002 C1 SS502-84-86 7/15/99 Field Duplicate	RPD	SE-020 C2 SS020-29-31 8/8/99 Primary	SE-020 C2 SS520-29-31 8/8/99 Field Duplicate	RPD	SE-020 C2 SS020-56-58 8/8/99 Primary	SE-020 C2 SS520-56-58 8/8/99 Field Duplicate	RPD
TPH (mg/kg)									
TRPH	6 J	8 J	29	274	283	3	1456	1458	0.1
Total hydrocarbons, C10-C39	100 U	100 U	--	1100	2600	81	6200	6000	3
C10-C11	--	--	--	280	660	81	1800	1700	6
C12-C13	--	--	--	290	660	78	1100	1000	10
C14-C15	--	--	--	250	550	75	1300	1300	0
C16-C17	--	--	--	150	340	78	1200	1200	0
C18-C19	--	--	--	85	190	76	410	420	2
C20-C21	--	--	--	51	120	81	420	420	0
C22-C23	--	--	--	20	60	100	67	65	3
C24-C25	--	--	--	7	20	96			--
C27-C28	--	--	--		10	-			--
C29-C30	--	--	--			--			--
C31-C32	--	--	--			--			--
C33-C34	--	--	--			--			--
C35-C36	--	--	--			--			--
C37-C39	--	--	--			--			--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SE-043 D2 SS043-23-25 8/9/99 Primary	SE-043 D2 SS543-23-25 8/9/99 Field Duplicate	RPD	SE-064 C2 SS064-34-36 9/6/99 Primary	SE-064 C2 SS564-34-36 9/6/99 Field Duplicate	RPD	SE-088 B1 SS088-24-25.8 9/6/99 Primary	SE-088 B1 SS588-24-25.8 9/6/99 Field Duplicate	RPD
TPH (mg/kg)									
TRPH	363	328	10	1111	1051	6	1507	1080	33
Total hydrocarbons, C10-C39	400	500	22	3700	3800	3	1600	3400	72
C10-C11	9	10	11	980	1000	2	330	720	74
C12-C13	83	100	19	830	850	2	270	560	70
C14-C15	210	250	17	770	790	3	300	630	71
C16-C17	63	73	15	480	490	2	270	580	73
C18-C19	10	15	40	320	330	3	210	400	62
C20-C21	5	6	18	190	190	0	120	300	86
C22-C23			--	94	98	4	66	100	41
C24-C25			--	44	44	0	30	30	0
C27-C28			--	22	22	0	14	30	73
C29-C30			--			-	6		--
C31-C32			--	9	8	12			--
C33-C34			--			--			--
C35-C36			--			--			--
C37-C39			--			--			--

Table 4-2 (Continued)
Summary of Field Duplicate Results
TPH in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SE-097 D2 SS097-92.6-94 9/7/99 Primary	SE-097 D2 SS597-92.6-94 9/7/99 Field Duplicate	RPD
TPH (mg/kg)			
TRPH	66	96	37
Total hydrocarbons, C10-C39	140	170	19
C10-C11	27	36	29
C12-C13	26	33	24
C14-C15	30	37	21
C16-C17	24	30	22
C18-C19	15	18	18
C20-C21	11	14	24
C22-C23			--
C24-C25			--
C27-C28			--
C29-C30			--
C31-C32			--
C33-C34			--
C35-C36			--
C37-C39			--

Notes:
J - estimated value
U - not detected at or above associated value
-- no value calculated
If nothing shown, no detection limit available

Table 4-3
Summary of Field Duplicate Results
TOC, PCBs, and Metals in Soil

Location ID Quadrant Sample ID Date Sampled Field QC	SB-028 C2 SB028-53.5-55 9/29/99 Primary	SB-028 C2 SB528-53.5-55 9/29/99 Field Duplicate	RPD	SB-057 C2 SB057-65-66 10/9/99 Primary	SB-057 C2 SB557-65-66 10/9/99 Field Duplicate	RPD	SE-008 C2 SS008-10.5-11.7 8/8/99 Primary	SE-008 C2 SS508-10.5-11.7 8/8/99 Field Duplicate		SE-079 C3 SS079-63-63.9 9/8/99 Primary	SE-079 C3 SS579-63-63.9 9/8/99 Field Duplicate	RPD
Conventional (mg/kg)												
Total organic carbon	--	--	--	--	--	--	--	--	--	330 J	1,000 J	101
PCBs (ug/kg)												
Aroclor 1016	--	--	--	--	--	--	300 U	300 U	--	--	--	--
Aroclor 1221	--	--	--	--	--	--	600 U	600 U	--	--	--	--
Aroclor 1232	--	--	--	--	--	--	300 U	300 U	--	--	--	--
Aroclor 1242	--	--	--	--	--	--	300 U	300 U	--	--	--	--
Aroclor 1248	--	--	--	--	--	--	300 U	300 U	--	--	--	--
Aroclor 1254	--	--	--	--	--	--	300 U	300 U	--	--	--	--
Aroclor 1260	--	--	--	--	--	--	300 U	300 U	--	--	--	--
Metals (mg/kg)												
Arsenic	12	7.8	42	3.8	3.2	17	--	--	--	--	--	--
Chromium	13	12	8	31	27	14	--	--	--	--	--	--
Copper	11	8.3	28	17	13	27	--	--	--	--	--	--
Zinc	31	29	7	38	32	17	--	--	--	--	--	--

J - estimated value

U - not detected at or above associated value

-- no value calculated

Table 4-4
Summary of Duplicate Results
Dioxins/Furans in Groundwater

Location ID Sample ID Date Sampled Field QC	DSW-4C GWDSW4C01 7/15/99 Primary	DSW-4C GW50A1201 7/15/99 Field Duplicate	RPD
Dioxins/Furans (pg/L)			
1,2,3,4,6,7,8-HpCDD	710	440	47
1,2,3,4,6,7,8-HpCDF	190	130	38
1,2,3,4,7,8,9-HpCDF	20 J	21 J	5
1,2,3,4,7,8-HxCDD	10 U	5 U	--
1,2,3,4,7,8-HxCDF	35 J	28 J	22
1,2,3,6,7,8-HxCDD	25 J	19 J	27
1,2,3,6,7,8-HxCDF	10 U	8.5 J	--
1,2,3,7,8,9-HxCDD	10 U	10 J	--
1,2,3,7,8,9-HxCDF	10 U	5 U	--
1,2,3,7,8-PeCDD	6 J	9 J	40
1,2,3,7,8-PeCDF	5 J	4.8 J	4
2,3,4,6,7,8-HxCDF	10 U	5 U	--
2,3,4,7,8-PeCDF	7 J	5 U	--
2,3,7,8-TCDD	5 U	5 U	--
2,3,7,8-TCDF	5 U	5 U	--
HpCDD's (total)	1,700	1,100	43
HpCDF's (total)	880	630	33
HxCDD's (total)	79	72	9
HxCDF's (total)	120	200	50
OCDD	7,300	4,700	43
OCDF	880	570	43
PeCDD's (total)	50 U	50 U	--
PeCDF's (total)	64	50 U	--
TCDD's (total)	10 U	10 U	--
TCDF's (total)	11	10 U	--
TEC (U/2)	35	27	26
TEC (U=0)	30	22	31

Notes:

J - estimated value

U - not detected at or above associated value

Bold values exceed the SAP QA/QC limits.

-- no value calculated

Table 4-5
Summary of Field Duplicate Results
SVOCs in Groundwater

Location ID Sample ID Date Sampled Field QC	A-5 GW000A501 7/12/99 Primary	A-5 GW50A1101 7/12/99 Field Duplicate	RPD	DSW-4C GWDSW4C01 7/15/99 Primary	DSW-4C GW50A1201 7/15/99 Field Duplicate	RPD
SVOC (µg/L)						
1,2,4-trichlorobenzene	10 U	10 U	-	10 U	10 U	-
1,2-dichlorobenzene	10 U	10 U	-	10 U	10 U	-
1,3-dichlorobenzene	10 U	10 U	-	10 U	10 U	-
1,4-dichlorobenzene	10 U	10 U	-	10 U	10 U	-
2,2-oxybis(1-chloropropane)	10 U	10 U	-	10 U	10 U	-
2,4,5-trichlorophenol	10 U	10 U	-	10 U	10 U	-
2,4,6-trichlorophenol	10 U	10 U	-	10 U	10 U	-
2,4-dichlorophenol	10 U	10 U	-	10 U	10 U	-
2,4-dimethylphenol	10 U	10 U	-	70	60 J	15
2,4-dinitrophenol	10 U	10 U	-	10 U	10 U	-
2,4-dinitrotoluene	10 U	10 U	-	10 U	10 U	-
2,6-dinitrotoluene	10 U	10 U	-	10 U	10 U	-
2-chloronaphthalene	10 U	10 U	-	10 U	10 U	-
2-chlorophenol	10 U	10 U	-	10 U	10 U	-
2-methylnaphthalene	10 U	10 U	-	1100	1000 J	10
2-methylphenol	10 U	10 U	-	10 U	10 U	-
2-nitroaniline	10 U	10 U	-	10 U	10 U	-
2-nitrophenol	10 U	10 U	-	10 U	10 U	-
3,3'-dichlorobenzidine	10 U	10 U	-	10 U	10 U	-
3-nitroaniline	10 U	10 U	-	10 U	10 U	-
4,6-dinitro-2-methylphenol	10 U	10 U	-	10 U	10 U	-
4-bromophenyl-phenylether	10 U	10 U	-	10 U	10 U	-
4-chloro-3-methylphenol	10 U	10 U	-	10 U	10 U	-
4-chloroaniline	10 U	10 U	-	10 U	10 U	-
4-chlorophenyl-phenylether	10 U	10 U	-	10 U	10 U	-
4-methylphenol	10 U	10 U	-	10 U	10 U	-
4-nitroaniline	10 U	10 U	-	10 U	10 U	-
4-nitrophenol	10 U	10 U	-	10 U	10 U	-
Acenaphthene	10 U	10 U	-	300	300	0
Acenaphthylene	10 U	10 U	-	7 J	7 J	0
Anthracene	10 U	10 U	-	20	20	0
Benzo(a)anthracene	10 U	10 U	-	10 U	10 U	-
Benzo(a)pyrene	10 U	10 U	-	10 U	10 U	-
Benzo(b)fluoranthene	10 U	10 U	-	10 U	10 U	-
Benzo(g,h,i)perylene	10 U	10 U	-	10 U	10 U	-
Benzo(k)fluoranthene	10 U	10 U	-	10 U	10 U	-
Benzyl alcohol	10 U	10 U	-	10 U	10 U	-
Bis(2-chloroethoxy)methane	10 U	10 U	-	10 U	10 U	-
Bis(2-chloroethyl)ether	10 U	10 U	-	10 U	10 U	-
Bis(2-ethylhexyl)phthalate	10 U	10 U	-	10 U	10 U	-
Butylbenzylphthalate	10 U	10 U	-	10 U	10 U	-
Carbazole	10 U	10 U	-	700	700	0

Table 4-5 (Continued)
Summary of Field Duplicate Results
SVOCs in Groundwater

Location ID Sample ID Date Sampled Field QC	A-5 GW000A501 7/12/99 Primary	A-5 GW50A1101 7/12/99 Field Duplicate	RPD	DSW-4C GWDSW4C01 7/15/99 Primary	DSW-4C GW50A1201 7/15/99 Field Duplicate	RPD
SVOC (µg/L) (Continued)						
Chrysene	10 U	10 U	-	10 U	5 J	-
Di-n-butylphthalate	10 U	10 U	-	10 U	10 U	-
Di-n-octylphthalate	10 U	10 U	-	10 U	10 U	-
Dibenzo(a,h)anthracene	10 U	10 U	-	10 U	10 U	-
Dibenzofuran	10 U	10 U	-	160	200	22
Diethylphthalate	10 U	10 U	-	10 U	10 U	-
Dimethylphthalate	10 U	10 U	-	10 U	10 U	-
Fluoranthene	10 U	10 U	-	20	30	40
Fluorene	10 U	10 U	-	130	100	26
Hexachlorobenzene	10 U	10 U	-	10 U	10 U	-
Hexachlorobutadiene	10 U	10 U	-	10 U	10 U	-
Hexachlorocyclopentadiene	10 U	10 U	-	10 U	10 U	-
Hexachloroethane	10 U	10 U	-	10 U	10 U	-
Indeno(1,2,3-cd)pyrene	10 U	10 U	-	10 U	10 U	-
Isophorone	10 U	10 U	-	10 U	10 U	-
N-nitroso-di-n-propylamine	10 U	10 U	-	10 U	10 U	-
N-nitrosodiphenylamine	10 U	10 U	-	10 U	10 U	-
Naphthalene	10 U	10 U	-	10000	10000	0
Nitrobenzene	10 U	10 U	-	10 U	10 U	-
Pentachlorophenol	30	30	0	10 U	10 U	-
Phenanthrene	10 U	10 U	-	110	100	9
Phenol	10 U	10 U	-	20	20	0
Pyrene	10 U	10 U	-	10	20	67

Notes:

J - estimated value

U - not detected at or above associated value

Bold values exceed the SAP QA/QC limits.

Table 4-6
Summary of Field Duplicate Results
Conventionals and Metals in Groundwater

Location ID Sample ID Date Sampled Field QC	A-5 GW000A501 7/12/99 Primary	A-5 GW50A1101 7/12/99 Field Duplicate	RPD	DSW-4C GWDSW4C01 7/15/99 Primary	DSW-4C GW50A1201 7/15/99 Field Duplicate	RPD
Conventionals (mg/L)						
Chloride	180	180	0	190	190	0
Nitrate as N	19	19	0	0.1 U	0.1 U	-
Nitrite as N	0.1 U	0.1 U	-	0.1 U	0.1 U	-
Sulfate	270	270	0	2	2	0
Total organic carbon	18	17	6	32	32	0
Metals (µg/L)						
Manganese (total)	20	20	0	380	360	5
Manganese (dissolved)	20	20	0	300	290	3

Note:

U - not detected at or above associated value

Table 4-7
Soil PAH/PCP Performance Evaluation Sample Results (in mg/kg)

Analyte	ERA QC Limits	SB906-144.0- 144.4 8/5/99	SB925-140.0- 140.2 8/27/99	SB961-138.2- 138.6 9/1/99	SS928-10.1-11 8/8/99	SS979-62-64 9/8/99
Acenaphthene	30.2 - 112	110	100	100	110	120
Anthracene	9.14 - 53.0	50	60	50	60	60
Benzo(a)pyrene	3.82 - 20.4	20 ¹	20 ¹	20 ¹	20 ¹	20 ¹
Fluorene	32.0 - 104	110	110	100	110	120
Naphthalene	14.3 - 102	100	100	90	80	90
Pentachlorophenol	112 ²	110	110	110	120	120
Pyrene	33.0 - 113	120	120	120	110	130

¹The reported laboratory results are within QC limits; however, if appropriate significant figures were used (i.e., same as used for the QC limits), then the results would be slightly greater than the QC limits.

²Certified value. ERA QC limits not available for pentachlorophenol.

Notes:

Bold values exceed the SAP QA/QC limits.

ERA - Environmental Research Associates, Inc.

Table 4-8
Soil TPH-Dx Performance Evaluation Sample Results (in mg/kg)

Analyte	ERA QC Limits	SB901001 8/4/99	SB930-204.0- 204.3 8/25/99	SB961-110.2- 110.6 8/31/99	SS908-10-12 8/8/99	SS997-105-106 9/7/99
TPH-Dx	838 - 2210	860	680	780	900	840

Notes:

QC limit exceedances are indicated in **bold**

ERA - Environmental Research Associates, Inc.

5.0 DATA INTERPRETATION/CONCEPTUAL SITE MODEL

5.1 PHYSICAL SYSTEM

5.1.1 Geology

5.1.1.1 *Regional Geology*

The City of Stockton is located on the margin of the Sacramento-San Joaquin delta near the axis of the Great Valley geomorphic province. The Great Valley is a sedimentary basin consisting of a series of homoclinal beds of clay, silt, sand, and gravel with a gently dipping east flank and more steeply dipping west flank (ICF Kaiser 1998). Stockton is located within the Sacramento sedimentary basin, which is separated from the San Joaquin sedimentary basin by the Stockton fault and the poorly defined Stockton Arch to the south of the project site. Approximately 6,000 feet of Quaternary and Tertiary alluvial deposits and sedimentary rocks overlie approximately 4,000 feet of Tertiary and Jurassic Melanges, which overlie crystalline basement rocks of the southwestward tilted Sierran block.

The California Department of Water Resources (DWR) mapped the surface geology of the McCormick and Baxter site as undifferentiated recent alluvium and Victor Formation. Quaternary flood basin deposits were mapped approximately 1 mile to the east of the site. The mid-Pleistocene to recent alluvium and Victor Formation overlie the Plio-Pleistocene Laguna Formation, which overlies the Mio-Pliocene Mehrten Formation. The flood basin deposits contain delta equivalents of the Victor and Laguna Formations (i.e., the Victor and Laguna Formations interfinger with flood basin deposits).

Flood basin deposits were described as consisting of silty clay, clayey silt, and micaceous silt that represent deposits on the time-transgressive flood plain of the San Joaquin River (Atwater 1982). The flood plain deposits were noted to have common calcium carbonate nodules and locally common black spherules of manganese and/or iron oxides.

The Quaternary Victor Formation is a heterogeneous assemblage of low-sloping alluvial fan and fluvial floodplain deposits derived from the Sierra Nevada (DWR 1967). The deposits consist of a heterogeneous sequence of gravel, sand, and clay. In the vicinity of the site, the thickness of this unit was shown to be approximately 170 feet (DWR 1967). The coarse-grained fluvial deposits of the Victor Formation reportedly grade laterally and vertically into the clays and silts of the flood basin deposits in a manner that "provides little correlation of material between wells" (DWR 1978).

Surface materials have more recently been mapped as Modesto Formation (CDMG 1990) and as fan deposits of the Calaveras River (Atwater 1982). The Modesto Formation represents Pleistocene glacial outwash fans that are approximately 10 to 15 feet thick. The Calaveras fan deposits are described as Quaternary fan deposits consisting of clayey silt, silt, sandy silt, and subordinate sand and gravel. Draining an unglaciated basin, the Calaveras River fan deposits are composed predominantly of lithic rock fragments and contain little mica. Because the Modesto Formation is derived from the Sierra Nevada, it is considered analogous to the Victor Formation for the purposes of this report.

The Plio-Pleistocene Laguna Formation underlies the Victor Formation. The Laguna Formation is interpreted to have been deposited as coalescing alluvial fans from the Sierra Nevada. The Laguna Formation consists of abundant beds of clayey silt and silty sand with some poorly graded sand in relatively thin zones and scarce well-graded gravel beds. It is lithologically similar to the Victor Formation, which makes the contact between the two formations difficult to discern visually. In the vicinity of the site, the Laguna Formation occurs between depths of approximately 170 to 1,000 feet bgs (DWR 1967). The Laguna Formation dips to the southwest and is derived from material eroded from the Sierra Nevada.

The Mehrten Formation lies beneath the Laguna Formation and is composed of moderately indurated andesitic sand and sandstone interbedded with tuffaceous silt and claystones. In the vicinity of Stockton, the Mehrten Formation is approximately 600 feet thick.

5.1.1.2 Site Geology

Prior to the collection of lithological data during this field investigation, the density of lithologic data deeper than 40 feet bgs was low, with data points spaced on average more than 400 feet apart. The new data set contains lithological data to approximately 100 feet bgs, spaced on average 75 to 100 feet apart. Deeper than 100 feet bgs, additional lithologic data are now available but are still relatively sparse. The geologic interpretations presented in this report are based upon all lithologic data collected to date, including the following: Old Mormon Slough sediment cores (SC-OMS series), RI borings (IB series), pre-RI geophysical and boring logs (A, DSW, EB, ONS, OFS, and OS series), SCAPS CPT data, grain size analysis data, SCAPS soil samples, and roto sonic soil borings.

Subsurface materials at the McCormick and Baxter site above 200 feet bgs were interpreted in the RI report (ICF Kaiser 1998) to be the flood basin deposits described by Atwater (1982). Sand and gravel deposits deeper than 200 feet bgs were interpreted in the RI report to be part of the Laguna Formation. Subsurface materials shallower than approximately 240 feet bgs (230 feet NVD88) encountered during the 1999 investigation summarized in this report consist primarily of two types. A uniform stiff to very stiff gray-green micaceous clayey silt with common calcite nodules and/or veins comprises approximately 60 percent of the subsurface

volume to 240 feet bgs. A gray to gray-green fine- to medium-grained sand and silty sand comprise the remaining 40 percent (Plates 2 through 7). Sedimentary structures such as laminations and cross-bedding are absent in the sands and silts. Contacts between the two materials are generally abrupt but occasionally are gradational. No significant lithological differences were observed in these two material types above and below 200 feet bgs.

The silt material was classified visually as clay in the majority of soil borings based primarily on its plastic nature. However, this material was determined to be silt with a large clay component based upon grain size analyses.

Sand zones exist as laterally continuous horizontal layers and as discontinuous layers and pods within and between the clayey silt material. These sand zones range in thickness from a few feet up to 30 feet thick. Most laterally continuous sand units are approximately 10 feet thick. The observed vertical and lateral relations of the sand and silt materials at the site are consistent with relations described for bedload channel (sand) deposits and flood basin overbank deposits (silt and clay) of a fluvial system, suggesting that the subsurface materials are the flood basin deposits described by Atwater. Bedload channel fluvial deposits typically display the following features, which are well represented in the geologic cross sections (Plates 2 through 7): channel fill is dominantly sand, channels have a high width-to-depth ratio, channels are slightly sinuous, individual channels are of uniform thickness across their width, bed accretion dominates over sediment infill, sands show irregular and poorly developed fining upward sequences, and multilateral sand channel fills commonly volumetrically exceed overbank deposits (Davis 1983). Since sand channel deposits represent a large percentage of the subsurface materials (approximately 40 percent), channels tend to overlap each other, allowing a high degree of horizontal and vertical connectivity of the sand deposits.

Some general trends regarding the occurrence of silts and sands in the subsurface are apparent. The percentage of subsurface volume occupied by sandy material is greater above an elevation of !100 feet (NVD88) than below. The sand units are well connected to !100 feet beneath the former Cellon Process Area extending to the southern boundary of the site. Silt generally predominates the subsurface materials below an elevation of approximately !180 feet and above the gravelly sand/sandy gravel unit at !240 feet elevation.

A sandy gravel/gravelly sand unit was encountered at approximately !240 feet elevation in 7 rotonic borings and 8 borings completed under previous investigations. This unit is laterally continuous and varies in thickness from 5 to more than 20 feet thick. The gravel and sand consists primarily of quartz/quartzite, volcanic, and metamorphic lithic fragments. These lithologies are similar to those discussed in the RI report (ICF Kaiser 1998). The sandy gravel/gravelly sand was interpreted by the authors of the RI report to be part of the Laguna Formation because the observed gravel lithologies are consistent with deposits from the

Calaveras River whose drainage is composed almost entirely from metamorphic and volcanic rocks.

The bottom of the sandy gravel/gravelly sand unit was penetrated at two locations (SB-004 and SB-052) during the 1999 field work described in this report. The gravelly unit was thinnest (approximately 5 feet) at SB052. Sand and silts encountered below the gravelly unit were similar to those encountered above.

Old Mormon Slough sediments and floodplain deposits below the slough were not investigated as part of the 1999 field work described in this report. However, shallow slough sediment data from the RI of the surface water operable unit (Battelle 1996) were incorporated into the geologic cross sections developed for this report. Sediments in the slough adjacent to the McCormick and Baxter site contain stratified clay, silt, and sand. The uppermost sediments consist of 1.4 to 3.8 feet of very soft, very dark gray to black, homogeneous clayey silt with common gas holes. Battelle interpreted these sediments to have been deposited in a quiescent, stagnant water environment (i.e., the current depositional conditions) after the channel was cut off from its upstream source in 1970 when Mormon Slough was partially filled and Interstate 5 was constructed. From the western edge of the sheet pile wall along the shoreline in front of the former Oily Waste Ponds to the eastern end of the slough, the uppermost sediments in the channel are underlain by a distinctive sticky, very soft, dark-gray clay layer approximately 1.5 to 2 feet thick. This material may have come from a manmade source (e.g., related to the infilling of portions of the slough in 1970 during the construction of Interstate 5) based upon the unusual texture and color of this material. The uppermost clayey silt layer and the gray clay are underlain by a soft to firm, very dark or dark olive-gray silt with plant remains and occasional discontinuous, thin sand layers. A sharp contact with the stiffer flood basin deposits was encountered at two sediment coring locations adjacent to the site uplands. The flood basin deposits were difficult to penetrate with the coring device and may have been the point of refusal at other locations.

5.1.2 Hydrogeology

The upper 200 feet of sediments are collectively referred to as the shallow aquifer. Groundwater in this zone occurs primarily in discontinuous sand layers and lenses of fine- to coarse-grained greenish-gray sand. The sediments from 200 feet bgs to at depth of at least 1,000 feet bgs in the vicinity of Newark-Sierra Paper Corporation (NSPC), located approximately 1,500 feet southeast of the site, have been termed the deep aquifer. The deep aquifer supplies industrial water to NSPC. Before 1993, three NSPC wells pumped 2 to 3 million gallons of water per day. Only two of the wells are still operational and currently pump 400,000 to 500,00 gallons per day. The results of a survey of local supply wells conducted by the USACE Sacramento District are provided in Table 5-1.

The horizontal and vertical overlapping distribution of relatively permeable versus impermeable materials in the subsurface above an elevation of !100 feet prohibits the presence of well-defined aquifers and aquitards. At this site, it is likely that the permeable sands and gravel units above !100 feet are interconnected vertically and horizontally by some pathway. Below !100 feet elevation, sand units may not be as well connected. However, the density of lithologic data below !100 feet elevation is sparse. Additional lithologic information at depth may show connectedness of the sands similar to that observed above !100 feet elevation.

Previous site investigations have divided the subsurface into five hydrogeological sand zones designated A, B, C, D, and E (Table 5-2). At well clusters where nearby wells are screened at different depths, thick clay sequences often separate the screened “aquifer” zones. However, the elevations of these aquifer zones are not consistent across the site and are likely to be connected by overlapping channel deposits elsewhere on the site. Generally, the aquifer zones are horizontally continuous across the site (e.g., the A-zone aquifer is continuous from the Cellon process areas to the southern boundary of the site property.) The sandy zones beneath the former Cellon Process Area (SE-08) extending toward the southeastern end of the stormwater retention ponds are well connected vertically, effectively connecting the A-, B-, and C-zones in this area (Plates 2 and 5). Therefore, the aquifer zone designation applies only locally to areas of the site where the silts are laterally continuous and not vertically bisected by sand channels.

5.1.2.1 Permeability

Laboratory permeability results (Table 3-8 and Figure 5-1) for sand material samples ranged from 6 millidarcies (0.017 ft/day) to 3,000 millidarcies (8.7 ft/day). Sand aquifer hydraulic conductivity values derived from pumping test data (ICF Kaiser 1998) yielded values ranging on average from 16 to 110 feet/day. The laboratory analysis measured vertical conductivity for the samples collected by the SCAPS rig (SS samples) and composite vertical and horizontal conductivity for the roto sonic samples (SB samples). Horizontal hydraulic conductivities were generated from pumping test data. SCAPS sand samples were collected directly into a plastic sleeve that was sent to the laboratory intact. Roto sonic sand samples were disturbed and repacked at the laboratory. Vertical conductivities for geologic materials are often one or more orders of magnitude lower than horizontal conductivities because sediments are typically deposited in horizontal layers. All permeability results reported by the laboratory and calculated for the pumping tests fall within published ranges (Domenico and Schwartz 1990).

Laboratory permeability results for the silt/clay materials ranged from 0.05 millidarcy (0.0001 ft/day) to 140 millidarcies (0.39 ft/day). Clay/silt aquitard hydraulic conductivities derived from pumping test data on average ranged from 0.0053 to 0.060 ft/day. The results of three samples classified as clay/silt have measured permeabilities (Figure 5-1) significantly higher than other measured permeabilities for clay/silt material. All three samples were collected using the SCAPS sampling tool. The SCAPS permeability samples are in a clear plastic sleeve when

brought to the surface, but can be difficult to describe accurately if silts and clays are smeared along the inside of the sleeve. Thus, sandy layers could be concealed and/or unnoticed in the visual soil description. Sample SS079-63.9-65 was described as having sand stringers, which could account for the high measured permeability. Sample SS093-25-26.7 was described as a sandy clay. The sand fraction may account for the higher permeability relative to the majority of clay/silt samples. Fractures were not observed in any of the silt samples collected.

All laboratory permeability results for clay/silt material were measured on intact, vertical samples. Pumping test hydraulic conductivity values were slightly higher than laboratory values. Pumping test vertical hydraulic conductivity calculations incorporate the sandy layers present between main aquifer zones and are thus biased high. All laboratory and pumping test values for hydraulic conductivity were within published ranges for clay and silt.

The E-zone gravel laboratory permeability measurements were 29 millidarcies (0.08 ft/day) and 240 millidarcies (0.70 ft/day). E-zone hydraulic conductivities derived from pumping test data averaged 130 ft/day. The laboratory samples were disturbed and repacked, which may account for part of the significant difference in results between the two methods. Laboratory results are low when compared to published values for gravel.

5.1.2.2 Water Quality

Groundwater beneath the site is generally of poor quality due primarily to high dissolved chloride concentrations (greater than 300 mg/L). From 1953 to 1963, the eastward edge of the 300-mg/L chloride contour migrated from approximately 0.5 mile east of the site to 1.0 mile east of the site (DWR 1967). Measured chloride concentrations in groundwater used by DWR to produce the 300-mg/L contour were mostly from wells deeper than 150 feet bgs. DWR noted that the delta within San Joaquin County generally contains groundwater of undesirable mineral quality throughout its entire surface area and from just below ground surface to the base of unconsolidated sediments. The few exceptions were local lenses of fresh water supplied from seepage from the delta channels and areas in the northwest portion of the county where surplus surface water and groundwater from the Mokelumne River system flushed out poor quality groundwater. The origin of the inferior quality groundwater was unknown but two possible sources were considered to be the most likely. Poor quality water may have accumulated in the trough of the valley and subsequently moved northward or was squeezed out of the trough by higher water levels or pressure from the south. Alternatively, poor quality water could be derived from rising saline connate water deposited with the deltaic sediments.

Chloride concentrations measured in monitoring wells sampled in July 1999 averaged 230, 180, 280, 310, and 550 mg/L in the A-, B-, C-, D- and E-zone wells, respectively. Based on these limited data, chloride concentrations appear to increase with depth at the site. A rapid increase in chloride occurs between the D- and E-zones. The abrupt increase in chloride (based on one data

point in the E-zone) provides evidence that groundwater in the E-zone is derived from a source that is different from that above the E-zone. Hence, the concept of an upper aquifer above 180 feet elevation and a lower aquifer below 180 feet elevation appears to be justified.

5.1.2.3 Tidal Influences

To evaluate the extent to which tidal fluctuations in Old Mormon Slough affect groundwater levels at the site, a tidal influence study was conducted for the A-zone aquifer in 1995. The results of the study concluded that there was insufficient response in water levels to show the effects of tidal ranges, and tidal effects were likely masked by daily changes in barometric pressure.

5.1.2.4 Groundwater Flow

The horizontal component of groundwater flow at the site is southeastward in the A-zone, turning gradually to the east-northeast with depth. An east-northeast E-zone flow direction is consistent with historical regional groundwater data (DWR 1967; ICF Kaiser 1998) that show a large groundwater cone of depression due to groundwater pumping centered over the central portion of the City of Stockton. The calculated horizontal velocities of groundwater in the A-, B-, C-, D- and E-zone sand units are 0.23, 0.20, 0.24, 0.048, and 0.29 ft/day, respectively. The vertical gradient of flow is downward between all aquifer zones, with a few limited exceptions of upward flow from the C- to B-zone. The calculated vertical groundwater flow velocities between aquifer zones A and B, B and C, C and D, and D and E are 0.00011, 0.000026, 0.000023, and 0.000063 ft/day, respectively. Calculated vertical groundwater flow velocities are three to four orders of magnitude less than horizontal groundwater velocities. Therefore, the predominant direction of groundwater flow and dissolved-phase contaminant transport is horizontal within sand zones. Vertical flow velocities were calculated assuming average thicknesses of silt and sand materials observed between clustered well screens. Vertical velocities are likely higher in areas where sand units have a strong vertical connection.

The southeasterly flow of groundwater within the A- through D-zones suggests that groundwater recharge of the upper aquifer is from the northwest and/or local pumping of the upper aquifer is to the southeast. The Stockton deepwater channel is north of the site, and the main channel of the San Joaquin River is west of the site. These are likely groundwater recharge sources for the upper aquifer.

Four lines of evidence suggest that Old Mormon Slough has a poor hydrogeologic connection to the upper aquifer. Groundwater elevations in A-zone wells are typically above water elevations in Old Mormon Slough. The A-zone groundwater gradient does not deflect or alter near the slough. Tidal fluctuations of up to 4 feet induced minimal response in A-zone wells (ICF Kaiser 1998). The bottom of the slough is blanketed with fine sediments that are likely to have low

permeability. Therefore, Old Mormon Slough does not have a strong hydraulic connection to the A-zone aquifer and is likely to contribute little if any water to the upper aquifer. Old Mormon Slough may contribute some water to the upper aquifer at the extreme northwest corner of the site in the vicinity of wells A-1 and A-10. The A-zone gradient near wells A-1 and A-10 is deflected from its average southeast trend and is roughly parallel to the slough (Figures 3-3 and 3-8), indicating that flow is from the north. Dredging of the slough in this area in 1987 may have opened a connection between the slough and the A-zone sands.

There is an apparent mounding of groundwater in the B-zone in the vicinity of wells ONS-2B and OFS-1B (Figures 3-4 and 3-9). Both of these wells are screened within thin sand zones surrounded by a thick continuous sequence of silt. It is possible that ONS-2B and OFS-1B are screened within sand zones that are separated by silt from the sands at the other B-zone wells. Water elevation measurements from ONS-2B and OFS-1B may, therefore, not respond to groundwater pressure changes at the same time as the other B-zone wells. The reason for the upward groundwater flow gradient between the B- and C-zones is not known, but may be related to the apparently poorly connected B-zone sands.

5.1.3 Physical Properties of NAPL

The NAPL density and viscosity data are summarized in Table 5-3. The density and dynamic viscosity results are similar (i.e., less than 10 percent relative percent difference) to measurements that were reported in the RI, as shown in Table 5-4.

5.1.3.1 *NAPL Density*

NAPL density data are presented in Table 3-20. All product samples were DNAPLs when collected at ambient temperatures, although the measured densities are very similar to water. At each temperature, three measurements were made and good reproducibility of the measurements was demonstrated. Measurements were made of duplicate samples from wells A-10 and ONS-1B. Although the data from the two samples from ONS-1B agreed well, the original set of density measurements made on the sample and duplicate from well A-10 showed significant differences. The density of both samples was remeasured, and the remeasured density for the A-10 sample is in very good agreement. For the duplicate sample, a lower density—closer to that of the A-10 sample—was measured. However, the average density found here is still statistically different from the A-10 sample measurements.

Density as a function of temperature is of interest in thermal remediation evaluations to determine whether further downward migration of DNAPL may be reduced or eliminated by making the DNAPL lighter than water at the same temperature. The data show that the product in DSW-6B may become an LNAPL at temperatures as low as 20°C, whereas the product in

A-10 will become an LNAPL at temperatures around 30°C. However, the product in ONS-1B will not become lighter than water even at temperatures as high as 90°C.

The average density curves for A-10, DSW-6B, and ONS-1B are presented in Figure 5-2.

5.1.3.2 NAPL Viscosity

NAPL viscosity data are presented in Table 3-21. At ambient temperatures, creosote generally has an approximate viscosity of 20 to 45 cP, and thus the product samples collected at the McCormick and Baxter site mostly cover the expected range for creosote. These viscosities mean that the NAPL would flow at rates 10 to 35 times less than the flow of water under the same gradient. However, the viscosity decreases exponentially as the temperature increases, and at temperatures approaching steam temperatures, the mobility of these NAPLs is increased by approximately a factor of 10. This increased mobility will aid NAPL recovery as a liquid during thermal remediation.

The average viscosity curves for A-10, DSW-6B, and ONS-1B are presented in Figure 5-3.

5.1.3.3 NAPL Boiling Point Distribution/Distillation

Based on the boiling point distillation data presented in Table 3-22, the NAPL recovered from A-10 consists of a mixture of hydrocarbons heavier than those from ONS-1B or DSW-6B. A-10 fractions separated at consistently higher temperatures than either ONS-1B or DSW-6B fractions. ONS-1B and DSW-6B distilled at the same temperatures between the zero to 30 percent volume fractions. Between 30 and 95 percent volumes, DSW-6B fractionated at lower temperatures, but was similar to ONS-1B between 95 and 100 percent distillation. The data also suggest that the DSW-6B NAPL contains the lightest molecular weight hydrocarbon mixture.

The boiling point distribution/distillation data are presented in Figure 5-4.

5.1.3.4 NAPL Saturation

NAPL soil saturation results were presented in Table 3-23. Hydrocarbon saturation ranged from less than 0.1 percent in SB-099 (13.4 to 14.7 feet bgs) and SB-028 (48 to 49.7 feet bgs), described at that depth as a clay with odor and a sand with sheen, respectively, to 77.0 percent in SB-099 (31 to 33 feet bgs), described at that depth as a sand with mobile NAPL.

5.1.3.5 NAPL Wettability

These data will be included in the Treatability Study Report.

5.1.3.6 *NAPL Solubility*

These data will be included in the Treatability Study Report.

5.1.3.7 *NAPL Oil-Water Interfacial Tension*

These data will be included in the Treatability Study Report.

5.2 CONTAMINATION SOURCE AREAS

5.2.1 Petroleum Hydrocarbon Product Type Identification and Location

The type of petroleum hydrocarbon contamination found in various areas of the site was identified as a factor that would have to be considered during conceptual design of an in situ thermal treatment system. To determine what different petroleum product types are present at the site, EPA Region 9 FASP laboratory TPH-Dx analysis chromatograms were reviewed. The TPH-Dx method is applicable for the identification of semivolatile petroleum products by pattern matching (or “fingerprinting”). Specific petroleum products (e.g., diesel fuel, creosote, hydraulic oil, lube oil) can be identified by comparing chromatograms from site samples to those of “pure” product standards. Often a laboratory will run a series of different “pure” products for this purpose. For this project, the FASP laboratory analyzed three standards:

- Florida TRPH standard (a mixture of even-numbered alkanes from C₆ to C₄₀)
- XHc diesel fuel No. 2 composite standard
- Creosote

If specific product types cannot be identified from comparisons to available standard chromatograms, patterns may still be observed that represent other unidentified product types or even naturally occurring organic materials. Unidentified patterns can be compared to each other and grouped to help characterize the site.

Laboratory TPH-Dx chromatograms for the SCAPS soil samples (approximately 80 samples) were reviewed. The TPH-Dx chromatograms for the soil boring samples were not available for review (approximately 400 samples). Five distinct patterns were observed (identified as A through E). Representative chromatograms and locations where these patterns were observed in samples collected from the site are shown in Plate 19. To confirm the results of the chromatogram review, laboratory results for SVOC, TRPH, TPH-Dx, and LIF were also reviewed. Laboratory results are listed in Table 5-5 for five representative samples. Results of this evaluation are summarized below.

Product type A was observed only in samples collected from location SE-43. The same pattern was observed in all samples collected from this location with positive TPH-Dx results. The petroleum pattern did not match that for diesel fuel or creosote and could not be identified. PAHs and PCP were not detected in samples collected from this location.

Product type B was observed only in samples collected from location SE-47. The same pattern was observed in all samples collected from this location with positive TPH-Dx results. The petroleum pattern did not match that for diesel fuel or creosote and could not be identified. PCP and low concentrations of PAHs were detected in samples from this location. Based on review of PAH/PCP chemical analysis results, this product type may be the carrier for PCP. PCP and a mixture of this product type pattern and product type D were observed in samples collected from location SE-88. PCP was also reported for many other samples in association with positive TPH-Dx results; however, without TPH-Dx chromatograms to review, product type identification cannot be confirmed (see Section 5.2.2).

Product types C and D were observed in numerous samples collected from the site. These two petroleum patterns are almost identical except for an unidentified peak (compound) present in product type D and not in product type C. The compound appears near C₁₀. Other than this difference, the patterns are very similar. Both product types contain numerous PAHs, including naphthalene, and closely resemble the pattern of the creosote standard. PCP was detected in approximately 20 percent of these samples.

Product type E was observed only in samples collected from location SE-28. The same pattern was observed in the two samples collected from this location with positive TPH-Dx results. The petroleum pattern did not match that for diesel fuel or creosote and could not be identified. PAHs and PCP were not detected in samples collected from this location.

5.2.2 Comparison of PAH/PCP Chemistry Across the Site

To determine what different petroleum product types are present at the site, an initial review of FASP laboratory TPH-Dx chromatograms was performed as described in Section 5.2.1. Product types A through E were identified. To extend this evaluation, EPA Region 9 laboratory PAH/PCP chemical analysis results were reviewed along with the FASP laboratory TPH-Dx chemical analysis results (including chromatograms) and the SCAPS LIF profiles. Results for approximately 375 soil samples analyzed for PAH/PCP were reviewed. Data for PCP, naphthalene, TPH-Dx, total PAH, and total cPAH were sorted by location and reviewed to identify additional locations across the site where the petroleum product types identified during the TPH-Dx chromatogram review are present. Only samples with positive results were maintained for the evaluation, resulting in a review of 128 samples collected from 26 locations.

During the review, characteristics of the different product types (e.g., distinct chromatographic pattern, presence of PCP, presence of PAH) were identified. Characteristics of the different product types are summarized in Table 5-6.

Using these characteristics as a guide, product types were assigned to sampling results. Samples with TPH-Dx chromatograms available for review have a higher level of confidence than samples without TPH-Dx chromatograms because pattern recognition is a better tool for petroleum product identification than chemistry results alone. Available SCAPS LIF profiles were reviewed as a final check on product type assignments; however, SCAPS profiles are useful only in identifying product types containing PAH. Distinct SCAPS LIF profiles were identified for products with fluorescing compounds (e.g., PAH), including product types A, C, and D. No distinct LIF patterns were evident for product types B and E. Product types B and E may contain PAH but at concentrations less than the sensitivity of the LIF method.

Product type assignments and supporting chemistry results are summarized in Table 5-7 for samples included in this evaluation. Product types assigned from review of TPH-Dx chromatograms are shown in bold.

5.2.3 NAPL Chemical Description

DNAPL was collected from ONS-1B, A-10, and DSW-6B and analyzed for petroleum hydrocarbons and SVOCs. Although LNAPL was measurable in some wells (i.e., A-8, ONS-1C, DSW-4B), the volume was insufficient for sampling. The product samples collected from A-10 and DSW-6B were emulsions that could not be separated in the field. The TPH-Dx analysis includes all organic compounds that fall into the C₁₀ to C₂₄ molecular weight range. The modified EPA Method 8015 used for the TPH-Dx analysis includes PAHs. The reported TPH concentration ranged from 916,000 ppm in ONS-1B to 131,000 ppm in DSW-6B. Presumably, the balance of these product samples would have been made up of shorter chain (less than C₁₀), lighter weight hydrocarbons and/or water. TPH chromatograms were not reviewed to identify specific product types.

SVOCs were detected in percent levels at each sampling location. Naphthalene was detected in concentrations that ranged from 130,000 ppm to 32,000 ppm in ONS-1B and DSW-6B, respectively. After naphthalene, the most abundant PAH is phenanthrene. Sample ONS-1B contained 33 percent PAHs.

Pentachlorophenol was detected in A-10 only (at 1,800 ppm). This finding is in agreement with the groundwater monitoring results, which indicate that PCP is found primarily in the A-zone.

All SVOCs included in the project target analyte list were detected in samples submitted for analysis. All NAPL samples contained a substantial portion of miscellaneous hydrocarbons that

were not identified. These likely derive from the various fuel oils and other petroleum products used as carriers in the original PCP and creosote mixtures. NAPL sampling results are presented in Section 3.9.1. Results from the 1999 NAPL sampling effort are consistent with NAPL data collected in 1997 (ICF Kaiser 1998).

5.2.4 Dioxin and Metals Extent of Contamination

2,3,7,8-TCDD TECs generally decreased with depth; however, the vertical extent of the dioxin contamination was not defined. Significant TECs were calculated at SB-008 (923,750 ng/kg 2,3,7,8-TCDD), where PCP crystals were detected on the ground surface, and at SB-057 (25, 207 ng/kg 2,3,7,8-TCDD) at 2.7 to 3 feet bgs. SE-008 is also located in an area where Cellon process activities occurred, and SB-057 is located directly in the Cellon process area. This contamination, as well as that at SB-028, likely occurs as a result of the NAPL contamination (as a function of the PCP dissolved in the creosote) detected in these areas; however, NAPL was not analyzed for dioxins and furans.

Chlorinated dioxin and furan congeners were detected at concentrations greater than 1,000 ng/kg in each sample collected. These concentrations were greatest in the shallowest depth interval sampled and generally decreased with depth, except at SB-057 (53.3 to 55 feet bgs) where all congener concentrations increased compared to the previous depth interval. Significant increases in concentration from the 48 to 49.7-foot depth interval to the 53.3- to 55-foot depth interval included 1,2,3,4,7,8-hexachlorodibenzofuran from undetected to 92 ng/kg, respectively; 1,2,3,4,6,7,8-heptachlorodibenzofuran from 450 to 1,600 ng/kg, respectively; octachlorodibenzofuran from 2,000 to 3,800 ng/kg, respectively; 1,2,3,6,7,8-hexachlorodibenzodioxin from 39 to 140 ng/kg, respectively; 1,2,3,4,6,7,8-heptachlorodibenzodioxin from 1,200 to 3,000 ng/kg, respectively; and octachlorodibenzodioxin from 7,000 to 27,000 ng/kg, respectively.

Insufficient data were collected to determine whether the pattern of dioxin/furan contamination occurring in the soil is the same as that detected in the groundwater at DSW-4 and DSW-6.

Metals (i.e., arsenic, chromium, copper, and zinc) were at detected fairly constant concentrations in each depth interval analyzed. The highest concentrations of each metal occurred in SB057 (2.7 to 3 feet bgs) where total PAH (TPAH) was low (i.e., 170) and TPH concentration was 2,200 mg/kg, which was not the highest concentration detected in the borehole.

Trends in metals (i.e., arsenic, chromium, copper, and zinc) concentrations were compared to trends in TPAH and TPH concentrations in each depth interval. Increases and decreases in metals concentrations are not equal to the magnitude of increases and decreases in TPAH and TPH concentrations. Trends (i.e., increases and decreases in concentrations) in arsenic concentrations are less frequently consistent with the trend in TPAH and TPH concentrations

than copper, chromium, and zinc. Chromium concentrations—more frequently than arsenic, copper, and zinc—exhibit the same concentration trend as those in TPAH and TPH concentrations. Further, some concentrations decreased in depth intervals where significant TPAH (i.e., 1,960 mg/kg) and TPH (i.e., 2,600 mg/kg) concentrations were detected. The data set collected is not sufficient to make a statistical determination of the concentration trend correlation between metals and PAH and TPH.

5.2.5 Source Area Description

The SCAPS LIF data were input into GMS to develop a three-dimensional representation of the site's contaminant profile, which can be found in the SCAPS investigation report (USACE 1999b). Since the LIF sampling frequency decreases significantly below depths of 120 feet bgs, the representation of the contaminant profile at depths greater than 120 feet bgs is incomplete. The shallowest zone of contamination was seen at less than 10 feet bgs, beneath the asphalt cap and in the former Oily Waste Pond area near SE-086, SE-087, and SE-088. The deepest zone of contamination was found in SB-06 (160 to 163 feet bgs) and SB-99 (210 to 215 feet bgs). The most widespread contamination was found in the 52.5- to 64.5-foot bgs interval across the site. NAPL contamination is suggested in limited, deep, isolated stringers at locations east of SE-79 (50 to 60 and 80 to 80.5 feet bgs) and in off-site areas southeast of the DSW-4 wells (75 to 140 feet bgs) and south of SE-97 (87 to 90, 90 to 95, and 100 to 102 feet bgs).

The SCAPS LIF data, observations made in the field, and the soil data suggest three primary NAPL source areas: (1) former Oily Waste Ponds Area, (2) Cellon Process Area, and (3) Main Processing Area. The data also suggest that NAPL has and continues to migrate away from these source areas, extending downward as well as outward to the south, west, and east. It also appears that the NAPL may also be migrating north of the property boundary, although no LIF data are available for locations north of the source areas.

PCP was detected in SCAPS soil samples collected at SE-05, SE-02, SE-08, SE-20, SE-88, SE-79, and SE-47. PCP was detected in roto sonic soil boring samples collected from SB-027, SB-028, SB-047, SB-057, SB-084, SB-086, and SB-099. Interestingly, some of the soil samples collected, such as SB-027, had reportable concentrations of PCP while PAHs and TPH-D were not detected. Soil PCP contamination appears to be associated with all three source areas. Crystals of almost pure PCP were found in a surface soil sample (EP-01) collected near SE-08. The Cellon process that took place in this area involved the use of PCP, butane, and ether.

Two unique near-surface (less than 30 feet bgs) source areas were identified near the entrance to the site at SE-43 and SE-47. The petroleum pattern in samples collected at these locations did not match that for diesel fuel or creosote and could not be identified.

5.3 OCCURRENCE OF NAPL

NAPL has been visually observed in soil borings as a brown to black liquid with strong naphthalene odor. NAPL saturation observed in soil cores has ranged from oozing and/or dripping product to brown stains and/or sheen. Dripping/oozing product was most commonly observed in sandy materials but also occurred in silt to a limited extent. The presence of NAPL in the subsurface has also been interpreted from SCAPS LIF data. NAPL is present within both the sand and silt materials identified in the subsurface. However, NAPL was observed more often in sand materials than in silt, and sandy material tended to be uniformly saturated with product in soil cores. NAPL within the clayey silt material was usually observed as discontinuous blobs of NAPL or as thin, vertically oriented NAPL stringers.

The shaded region shown in Plates 2 through 7 represents the subsurface volumes interpreted to contain NAPL. NAPL within the shaded region may occur as mobile NAPL, residual NAPL, pools of DNAPL on low-permeability silt, or thin, vertically discontinuous fingers/stringers. DNAPL may not be present everywhere within the shaded regions. The outer boundary of the shaded region represents the likely maximum extent of NAPL in the subsurface where the vertical and horizontal data density is adequate to define the extent of NAPL. The data density above approximately 100 feet elevation is high and the maximum extent of NAPL above this elevation is well characterized. Below 100 feet elevation, data are relatively sparse. Therefore, NAPL pathways and the maximum horizontal and vertical extent of NAPL below 100 feet elevation are less certain.

The interpreted maximum horizontal extent of NAPL in the subsurface is shown as a solid and dashed line in Figures 5-5 through 5-8. The dashed portion of the boundary indicates areas where NAPL is present but beyond which only limited data are available. Data are insufficient to determine whether NAPL extends beyond the property line at the dashed locations.

5.3.1 Vadose Zone

NAPL, which was presumably released at or near the surface, has moved down through the clayey silt material that comprises the upper 20 to 30 feet of the subsurface. The water table was present within this uppermost clayey silt layer in April and July of 1999. The water table was lower during past measurement events and may have intersected the A-zone sands. The clayey silt layer clearly does not act as an effective barrier to vertical NAPL migration. The dominant direction of NAPL migration within the vadose zone is downward based upon the lack of vadose zone NAPL at locations other than near the suspected source areas.

The majority of NAPL has migrated below the water table as DNAPL. However, NAPL appears to extend along the present water table from the blacktop area southeast to SE-94 (Plate 7). A

large tank was located directly east of SE-94, and it is possible that a spill occurred near or from this tank. NAPL from a spill associated with this tank may not have penetrated deeply.

The shallowest occurrences of NAPL in the vadose zone are beneath the former Oily Waste Ponds Area, the Cellon Process Area, and the asphalt cap that covers the former Main Processing Area (Figure 5-5). The largest net thicknesses of NAPL (Figure 5-8) are also in these three areas. Based upon the presence of vadose zone NAPL and the net thickness of NAPL beneath these areas, these three areas are the most likely source areas of NAPL contamination in the subsurface.

5.3.2 Saturated Zone

DNAPL has migrated from the water table to a maximum observed depth of 212 feet bgs (approximately 1200 feet elevation). DNAPL is interpreted as having migrated in the saturated zone by moving vertically through permeable sand units, spreading laterally in sands on top of sloping low-permeability silts, pooling on low-permeability silts, and migrating vertically through silts.

The manner by which DNAPL is able to move through the relatively impermeable silts is not known. DNAPL was observed to be present in the silts as discontinuous blobs of NAPL and as thin vertically oriented stringers. Fractures were looked for, but were not confirmed in any soil cores in any borings. Apparently, the NAPL is able to move through the pore space within the silts.

DNAPL has migrated downward and to the south from the Oily Waste Ponds/Cellon Process Area to a maximum observed depth of 100 feet at the southern boundary of the site and to a depth of 130 feet in the vicinity of SE-61 (Plate 6 and Figures 5-5 and 5-6). The deepest observed occurrence of DNAPL is beneath the Main Processing Area (SB-099) at 212 feet bgs. The Main Processing Area is also a suspected NAPL source area, and vertical migration in this area has been dramatic. DNAPL is interpreted to have moved vertically through multiple low-permeability silt layers (Plates 4 and 7). DNAPL has also migrated laterally and downward from the Main Processing Area toward the southeast (SE-93) and the UPRR property line (as approximated from parcel maps) and toward the south to the southern boundary of the McCormick and Baxter property near the main gate (Plates 4 and 7).

DNAPL may have migrated beyond any or all of the dashed portions of the NAPL boundary shown in Figure 5-5. DNAPL along Old Mormon Slough is present at shallow elevations ranging from 8 feet elevation to 145 feet elevation. Deeper DNAPL is also present adjacent to the slough in the vicinity of the Main Processing Area from elevations as deep as 160 to 160 feet. Thus, DNAPL could have migrated under the slough to the north along a broad margin and at various depths. DNAPL could potentially have migrated onto the UPRR property east of SE-79 and SE-93 at elevations of 140 to 170 feet. DNAPL may also have migrated past

the southern property boundary at the main gate and the southeast corner of the stormwater retention ponds at elevations ranging from !50 to !100 feet and !80 to !90 feet, respectively.

5.3.3 Volume Estimates

NAPL occurrence data, compiled from this investigation and previous subsurface exploration efforts, was used to map product distribution and estimate site-wide NAPL volumes. The elevations at which NAPL was detected in a boring or SCAPS push are listed in Table 5-5. The shallowest depth NAPL was encountered at each location is given in the "top NAPL" column in Table 5-8. These depths were chosen on the basis of significant staining or sheen, free-product visual observation, chemical analyses, and/or LIF response. The deepest point at each location where NAPL was encountered is shown in the "base max NAPL" column. If a particular sampling location did not reach a depth comparable to nearby locations with observed NAPL at that depth or greater, this location was not used for analysis. The total number of feet at each subsurface location interpreted to contain NAPL is shown in the "net NAPL" column. The net thickness of NAPL is not necessarily equal to the distance between the top of NAPL and the bottom of NAPL at any individual location because intervals of non-NAPL contaminated soil were often encountered between the top and bottom of observed NAPL. All NAPL surfaces are truncated where areas of NAPL contamination intersect site boundaries because off-site data are limited to widely spaced monitoring wells.

The data in Table 5-8 were used to create the surface plots shown in Figures 5-5 through 5-8. The top of NAPL contours (Figure 5-5) represent the highest elevations where NAPL was observed in the subsurface across the site. The surface contours in Figure 5-6 represent the deepest on-site elevations of NAPL encountered in the subsurface. The volume of space between the two surfaces is approximately 23,000,000 ft³ (850,000 yd³). Therefore, the total volume of space that exists between the shallowest and deepest known occurrences of NAPL is 23,000,000 ft³.

A third surface (Figure 5-7) was created to represent the base of NAPL at an elevation of !100 feet and above. Data suggest that the bulk of the NAPL is present above !100 feet elevation. NAPL below this elevation is apparently present in small quantities and occurs in thin, hard-to-locate stringers. The volume of space between the surfaces shown in Figures 5-5 and 5-7 is approximately 20,000,000 ft³ (740,000 yd³). Therefore, the total volume of space that exists between the shallowest known occurrences of NAPL and an elevation of –100 feet is 20,000,000 ft³.

The thickness of NAPL-contaminated soil at each boring/push was determined by adding together the intervals of observed and interpreted NAPL at each sampled location to derive a net total thickness at each location. The net thickness, therefore, is not necessarily equal to the distance between the top and bottom of observed NAPL at any particular location. Figure 5-8 is

an interpreted contouring of the net interpreted soil containing NAPL. The net thickness of NAPL is useful in order to estimate the volume of NAPL present in the subsurface because only portions of the subsurface that contain NAPL are used in the calculation. The volume of soil contaminated with NAPL represented by the net thickness map is approximately 6,000,000 ft³ (220,000 yd³). Assuming a porosity of 0.35 and values of NAPL saturation in the pore space of 1 percent and 10 percent (the approximate range of NAPL saturation data presented in Table 3 - 23), yields a volume of NAPL in the subsurface of 160,000 and 1,600,000 gallons, respectively.

5.4 DESCRIPTION OF GROUNDWATER CONTAMINATION

Naphthalene, PAHs, dioxins, PCP, and arsenic were identified as indicator chemicals of the extent of dissolved-phase groundwater contamination in the RI report (ICF Kaiser 1998). Of these chemicals, naphthalene, PCP, and dioxins were targeted for analysis during the July 1999 sampling event.

5.4.1 Changes From 1998 Data

NAPL has been present at some time either as an unmeasurable oily film or as significant DNAPL in five of the wells sampled in July 1999. The presence or absence of NAPL in a well is likely to have a large influence on the concentration of dissolved-phase contaminants in the groundwater. Prior to the July 1999 sampling round, wells were sampled by purging three well volumes at a high rate (approximately 15 gpm). In July 1999, wells were sampled using the low-flow sampling method with flow rates approximately 0.5 gpm. NAPL may be less likely to be entrained with groundwater when the low-flow procedure is used. Therefore, it is possible that previous sampling chemical results may have been biased high when NAPL was present in the well.

5.4.1.1 Naphthalene

Dissolved-phase naphthalene concentration changes were generally insignificant between 1998 and 1999 and between 1999 and earlier dates. Naphthalene concentrations were significantly different in two wells, A-8 and DSW-6C. Naphthalene was much lower in well A-8 than in the recent past but was about equal to the lowest value measured since monitoring began. Because well A-8 is located in a zone known to be contaminated with NAPL, large variations in naphthalene concentrations are expected. Concentrations of naphthalene in well DSW-6C rose sharply from 1998 to 1999. This sharp increase could be due to downward NAPL migration from the B- to the C-zone or lateral migration of NAPL in this area.

5.4.1.2 PCP

Dissolved-phase PCP concentration changes were generally insignificant between 1998 and 1999 and between 1999 and earlier dates. PCP concentrations changed significantly only in well A-5, where PCP concentrations decreased from 1998 levels. PCP concentrations have decreased steadily in this well since monitoring began.

5.4.1.3 TCDD TEC

TCDD TEC concentrations in well A-5 decreased significantly from 1997 to 1999. An oily sheen was noted on the purge water surface during sampling in 1997, and no NAPL was noted in 1999. The TCDD TEC concentration in well DSW-4B increased sharply from 1998 to 1999, but the 1999 value was still well below the peak values of 1996 and 1997. DNAPL and LNAPL were measurable in the well during 1997, and an oily film of LNAPL was noted in July 1999. The TCDD TEC concentration in well DSW-4C has decreased significantly since 1996 when NAPL was present in the well. No NAPL was noted in 1999. TCDD TEC concentrations in well DSW-6B were much lower in 1999 than in 1996 and 1997. Well DSW-6C has had measurable NAPL in all three events. Six well volumes were purged from well DSW-6C during the RI. Excessive pumping may have entrained NAPL with the groundwater sample. The TCDD TEC concentration in wells DSW-6C, OFS-3B and DSW-4D did not change significantly.

5.4.2 Summary of Extent of Groundwater Contamination

The extent of dissolved-phase contamination was investigated and discussed in the RI report (ICF Kaiser 1998). The RI conclusions regarding groundwater contamination are summarized here, and the results of groundwater analyses for naphthalene, PCP, and TCDD TEC are summarized with the interpreted groundwater elevation contours for April 1999 in Plates 8 through 18. The April 1999 groundwater elevation data are presented with groundwater concentration data. Since the groundwater gradients and flow directions have not changed significantly with time or season, the April 1999 groundwater elevation contours are representative of steady-state conditions at the site. Conclusions from the RI were reinterpreted to account for new information regarding the presence of NAPL in the subsurface and new groundwater concentration data.

5.4.2.1 Naphthalene

Naphthalene is present dissolved in groundwater in aquifer zones A through E. In A-zone wells, significant concentrations of naphthalene are only in wells known to contain NAPL (A-8, ONS-2A, and A-10) or in areas where NAPL is interpreted to be present or nearby in the A-zone (ONS-2A) based upon the results of this 1999 investigation (Plate 8). Naphthalene

concentrations at wells located within the interpreted volume of NAPL, or near NAPL-contaminated wells, are within or above the effective solubility concentrations calculated for naphthalene in the RI (6,000 to 15,000 µg/L). One exception to this trend is well A-1, which is upgradient of all known source areas and had high (90 to 170 µg/L) concentrations in the late 1980s, but has otherwise had concentrations that were nondetected or less than 10 µg/L. It is possible that dredging of the slough in 1987 opened a temporary hydraulic connection between the slough and the A-zone sands, allowing a slug of naphthalene-contaminated water to flow through well A-1.

A-zone wells located outside, but immediately downgradient, of the A-zone area containing NAPL have low to nondetected levels of dissolved-phase naphthalene. This suggests that naphthalene has not traveled far ahead of the NAPL plume in the A-zone at significant levels or that A-zone wells downgradient of NAPL are not hydraulically connected to NAPL-contaminated soils. Assuming that hydrophobic sorption of is the primary mechanism controlling the movement of dissolved phase naphthalene in groundwater, a retardation factor relating the velocity of naphthalene transport to the velocity of groundwater flow can be calculated using the following formulae:

$$\begin{aligned}K_d &= K_{oc} \times f_{oc} \\ \rho_s &= \rho_b / (1-n) \\ R_f &= 1 + ((1-n)/n) \times \rho_s \times K_d\end{aligned}$$

Where K_d is the distribution coefficient, K_{oc} is the partition coefficient of a compound between organic carbon and water, f_{oc} is the weight fraction of organic carbon, ρ_s is the density of the minerals comprising the soil, ρ_b is the bulk density of the soil, n is the soil porosity, and R_f is the retardation factor relating the velocity of the contaminant to the velocity of groundwater. Using a literature-derived value of 933 for K_{oc} (Battelle 1996) and an f_{oc} of 0.001 yields a K_d of 0.93 for naphthalene. Site-specific f_{oc} data were not used because site f_{oc} values were generally less than 0.1 percent. The retardation model used is useful only for values of f_{oc} of 0.1 percent or higher; therefore, 0.1 percent was used as the minimum value. Using a ρ_b of 1.71 g/cc (calculated from site specific data) and a porosity of 0.38 yields a R_f of 5.15 for naphthalene. Therefore, naphthalene is anticipated to migrate at one-fifth the velocity of groundwater. Assuming that groundwater velocity in the A-zone sand unit is 0.2 ft/day and that 45 years have elapsed since contamination entered the groundwater, yields a maximum travel distance of 640 feet for naphthalene. However, down-gradient wells that are within 640 feet of known source areas (e.g., A-4, A-5, A-6 and A-7) have measured naphthalene concentrations that are low (less than 30 µg/L or not detected). Dispersion alone is unlikely to account for the low concentrations observed ahead of the NAPL plume. Therefore, some other mechanism (e.g., biodegradation) may be responsible for the lack of significant dissolved-phase contamination ahead of the NAPL plume.

Four B-zone wells (ONS-1B, DSW-4B, DSW-5B, and DSW-6B) have naphthalene concentrations near, within, or above the range of effective solubility for naphthalene calculated in the RI (Plate 9). All four of these wells are screened within the area interpreted to have NAPL in the B-zone and/or NAPL has been detected in the well. As with the A-zone, B-zone dissolved-phase naphthalene concentrations downgradient of interpreted B-zone NAPL contamination are nondetected or are low (less than 10 µg/L). Naphthalene concentrations in well ONS-2B are also low to nondetected suggesting that dissolved-phase naphthalene has not migrated vertically ahead of the DNAPL and/or that the B-zone is not hydraulically connected to the A-zone in the vicinity of the ONS-2 wells.

Three C-zone wells (ONS-1C, DSW-1C, and DSW-4C) have naphthalene concentrations near, within, or above the RI calculated effective solubility range (Plate 10). Wells ONS-1C and DSW-4C are screened within the interpreted NAPL contaminated area of the C-zone. Well DSW-1C is not located within the area interpreted to be contaminated with NAPL. It is possible that NAPL may be present at or near this well. SCAPS information is not available for this depth, but C-zone NAPL contamination is present beneath the asphalt cap. NAPL could have migrated from beneath the asphalt cap to well DSW-1C and would not have been detected by the 1999 NAPL investigation. As with the A- and B-zones, wells downgradient of known C-zone NAPL contamination generally have low or nondetected naphthalene concentrations. Two exceptions are wells DSW-6C and ONS-2C. In well DSW-6C, naphthalene concentrations are now 800 µg/L and have been generally increasing with time. NAPL contamination from the B-zone may be migrating downward to the C-zone. Naphthalene concentrations in well ONS-2C have been moderate (17 to 26 µg/L). No NAPL has been interpreted to be present in the C-zone near this well. However, LIF response was noted at SCAPS locations SE22 and SE60 at depths that fall between the B- and C-zones. The LIF response was at or below the 300 count limit at both locations at the suspect depths, so NAPL was interpreted to not be present. It is possible that a thin stringer of NAPL may have moved down to between the B- and C-zones (80 to 90 feet bgs) in this area.

Two D-zone wells (DSW-1D and OFS-4D) have naphthalene concentrations near, within, or above the RI calculated effective solubility (Plate 11). DSW-1D is outside the current interpreted NAPL-contaminated area, but NAPL could be present at or near this well for the same reasons given for DSW-1C above. Well OFS-4D is located off site approximately 500 feet southeast of the DSW-4 wells. No additional NAPL information is available between OFS-4D and the site boundary. However, the concentrations measured in OFS-4D indicate that NAPL is likely present nearby in the D-zone since naphthalene does not appear to be present dissolved in groundwater very far ahead of the DNAPL source. Naphthalene concentrations in well ONS-1D have risen steadily with time, suggesting that NAPL contamination from the C-zone may be migrating downward to the D-zone at this location. Naphthalene concentrations in well ONS-2D were inconsistent between the two measurement events. The presence of dissolved-phase naphthalene in well ONS-2D is consistent with naphthalene detected in ONS-2C, suggesting a

strong hydraulic connection between the two wells and/or deep NAPL migration. Few D-zone wells are present downgradient of suspected NAPL zones so it is not possible to describe the potential extent of dissolved-phase contamination beyond the suspected NAPL boundaries.

Except for well OFS-4E, all E-zone naphthalene concentrations are nondetected or very low (Plate 12). Naphthalene concentrations in well OFS-4E have declined steadily with time, from 3,600 to 600 $\mu\text{g/L}$. Initial naphthalene concentrations in this well were high enough to indicate NAPL was nearby.

5.4.2.2 PCP

PCP is generally present in groundwater when naphthalene is present at concentrations high enough to be indicative of NAPL presence (Plates 13 through 17). PCP concentrations are generally lower than naphthalene, presumably due to the lower calculated solubility of PCP (2,000 to 5,000 $\mu\text{g/L}$). The concentration and extent of dissolved-phase PCP generally decrease with depth in the aquifer until PCP is essentially nondetected within the D- and E-zones.

The distribution of PCP in the A-zone, however, deviates substantially from that of naphthalene (Plate 13). PCP is present in wells at concentrations near, within, or above its calculated effective solubility within the interpreted area of NAPL contamination and known NAPL-contaminated wells (A-10, ONS-2A, and A-8). However, PCP has also been detected near, within, or above its calculated effective solubility levels in A-zone wells downgradient of the NAPL-contaminated wells (A-4, A-5, and A-6) and areas of interpreted NAPL contamination. PCP concentrations (approximately 20 to 120 $\mu\text{g/L}$) in well A-3 have also been higher than naphthalene concentrations which were generally nondetected.

Based upon partitioning coefficient data, PCP should be approximately 50 to 60 times more retarded in groundwater than naphthalene. The lack of observed PCP contamination beyond interpreted NAPL zones in the B-, C-, D- and E-zones, to the degree that PCP is present ahead of interpreted NAPL-contaminated areas in the A-zone, suggests that a different mechanism is at work for PCP migration in the A-zone. One possibility is a separate, unobserved NAPL carrying the PCP in the A-zone. Alternatively, there may be PCP-contaminated source areas outside of the interpreted creosote NAPL area that are acting as long-term sources to shallow groundwater contamination.

5.4.2.3 Dioxins and Furans

Dioxin is present in dissolved-phase groundwater and shares some of the distribution patterns mentioned in Sections 5.4.2.1 and 5.4.2.2 for naphthalene and PCP (Plate 18). Dioxin data are sparse, but some general trends are evident. Dioxin is present in all aquifer zones and in wells where naphthalene concentrations or other data indicate that NAPL is present or nearby. Dioxin,

like PCP, is also present in A-zone wells (A-3, A-5, and A-6) outside and downgradient of the interpreted NAPL-contaminated area. Dioxin is likely transported as an impurity of the PCP contamination by one of the mechanisms described above.

5.4.3 Natural Attenuation Parameters

A series of water quality and natural attenuation parameters were measured for the monitoring wells sampled during this investigation. The parameters were collected to begin assembling data for a study of natural attenuation at the site. Additional wells and sampling rounds will be required before conclusions can be drawn from the data collected during this investigation.